July 18, 1960

missiles and rockets

THE MISSILE/SPACE WEEKLY

DETROIT PUBLIC L
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TECHNOLOGY
DEPARTMENT

GE's Thermionic Converters

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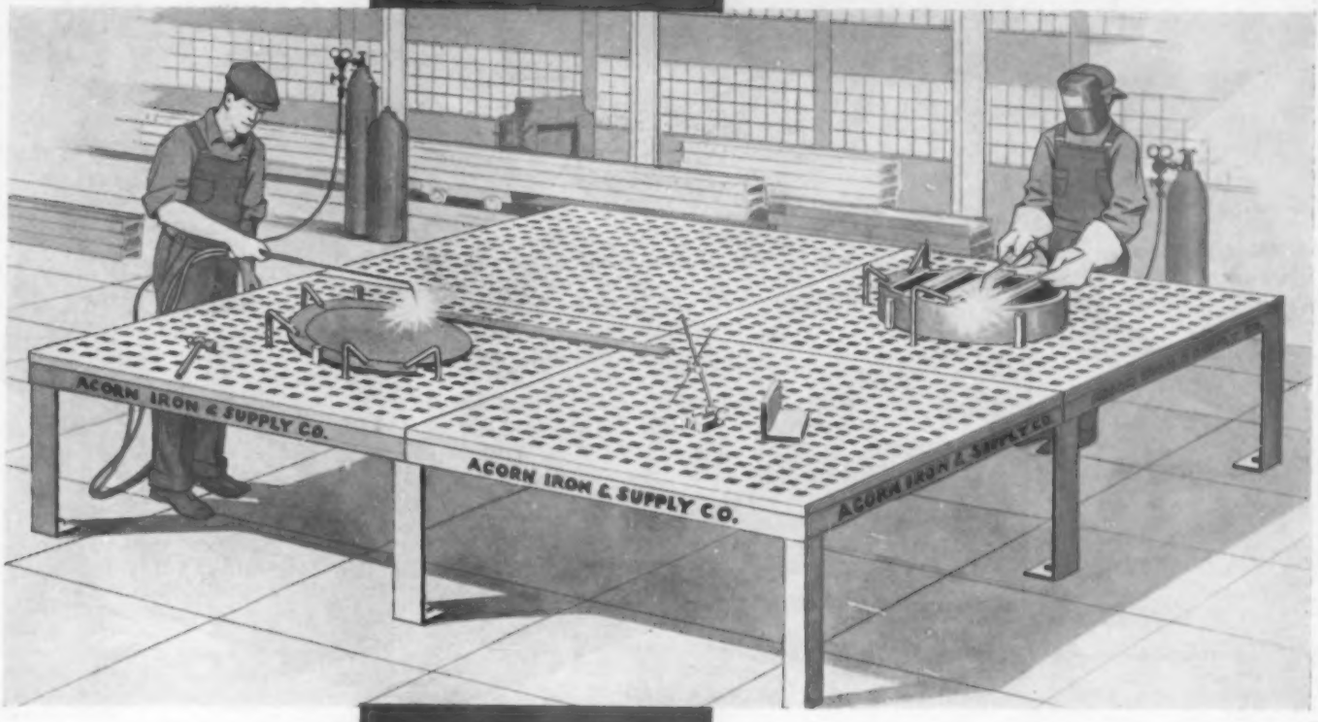

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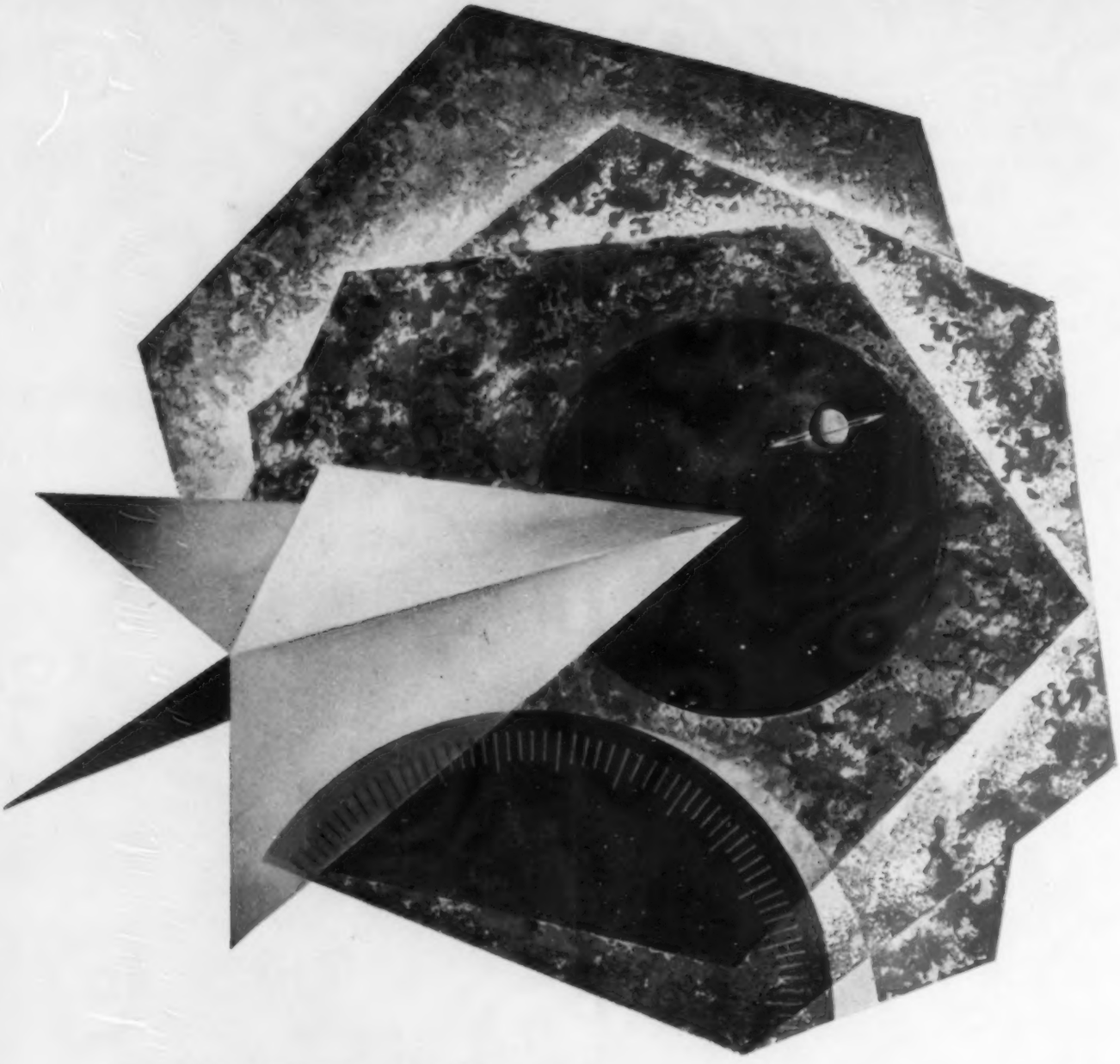

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missiles and rockets

July 18, 1960 Volume 7, No. 3

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THE COVER

GE engineer checks a group of production type thermionic converters. Developed for use in auxiliary power systems for space vehicles, each unit has one-watt output.

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Including for the first time a directory of rocket engines

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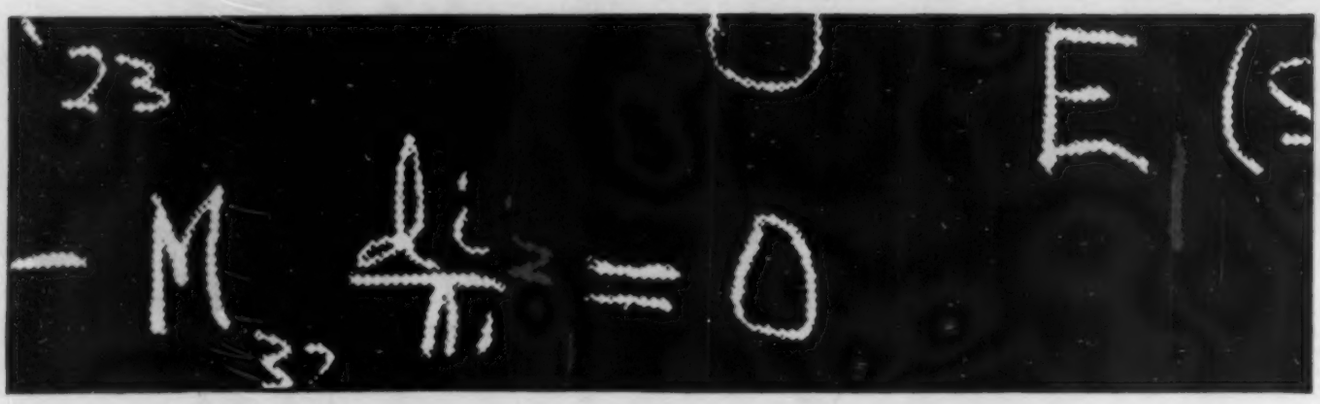
39,420 copies this issue



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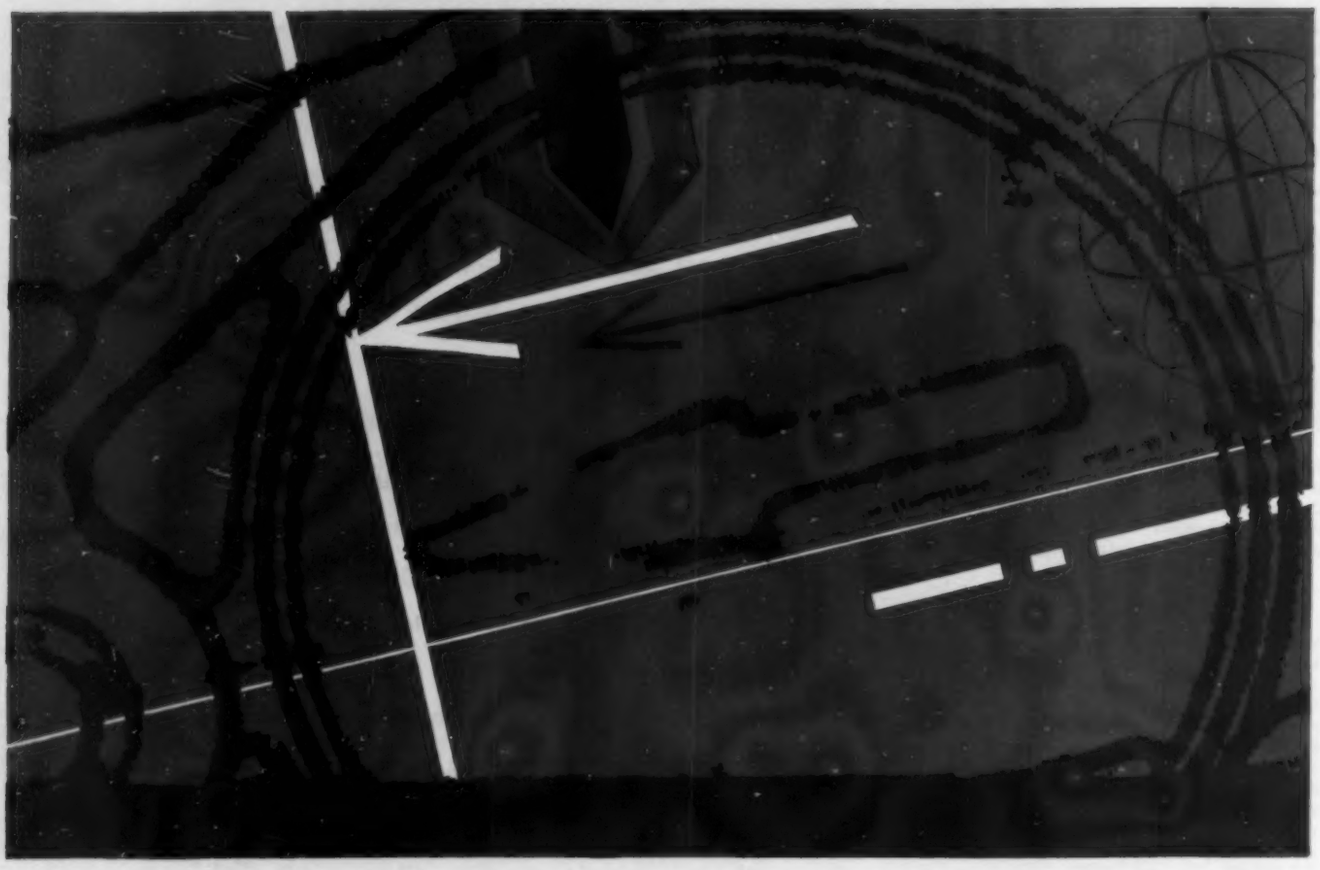

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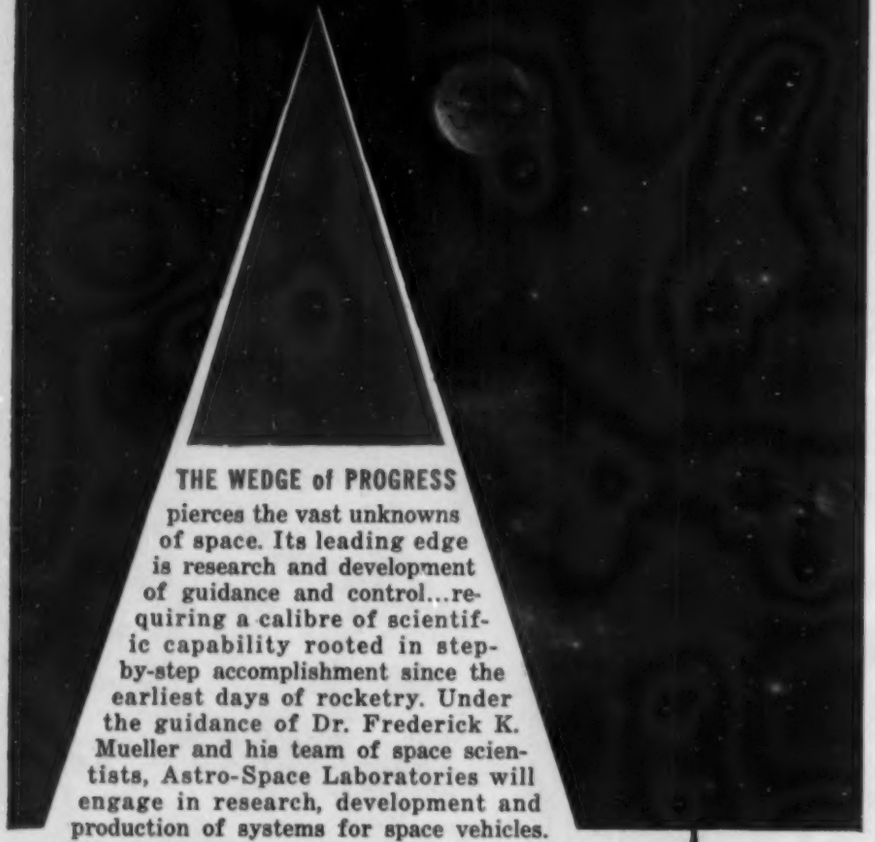

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American Rocket Society, Propellants Combustion and Liquid Rockets Conference, Ohio State University, Columbus, July 18-19.

Third International Conference on Medical Electronics, sponsored by Institution of Electrical Engineers, Olympia, London, July 21-27.

Pennsylvania State University R&D Management, Development Seminar, University Park, July 24-29.

Thermochemistry of Rocket Propulsion, a short course, University of Calif., Los Angeles, July 25-Aug. 5.

Denver Research Institute, Seventh Annual Symposium on Computers and Data Processing, Stanley Hotel, Estes Park, Colo., July 28-29.

AUGUST

4th Global Communications Symposium, co-sponsored by IRE, Prof., Group on Communications Systems, and U.S. Signal Corps (100th Anniversary), Statler-Hilton Hotel, Washington, D.C., Aug. 1-3.

Massachusetts Institute of Technology, Special Summer Program on Modulation Theory and Systems, Cambridge, Aug. 1-12.

International Symposium on Rarefied Gas Dynamics, University of Calif., Berkeley, Aug. 3-6.

University of Connecticut, Institute for Practical Research on Operations, Storrs, Aug. 7-13.

University of Connecticut, Third Annual Institute on Missile Technology, Storrs, Aug. 7-19.

American Astronautical Society, Western National Meeting, Olympic Hotel, Seattle, Aug. 8-11.

American Institute of Electrical Engineers, 1960 Pacific General Meeting, El Cortez Hotel, San Diego, Calif., Aug. 8-12.

ASME-AIChE Heat Transfer Conference and Exhibit, Statler Hilton, Buffalo, N.Y., Aug. 15-17.

XIth International Astronautical Congress, International Astronautical Federation, Stockholm, Aug. 15-20.

Cryogenic Engineering Conference, University of Colorado and NBS, Boulder, Colo., Aug. 23-25.

Western Electronics Show and Convention, Los Angeles Memorial Sports Arena, Los Angeles, Aug. 23-26.

International Union of Pure and Applied Physics, International Conference on High Energy Nuclear Physics, University of Rochester, Rochester, Aug. 25-Sept. 3.

The German Rocket Society, Annual Meeting, Hanover, Germany, Aug. 26-28.

University of Connecticut, Eleventh Annual Basic Statistical Quality Control, Storrs, Institute, Aug. 28-Sept. 9.

The Combustion Institute, 8th Interna-

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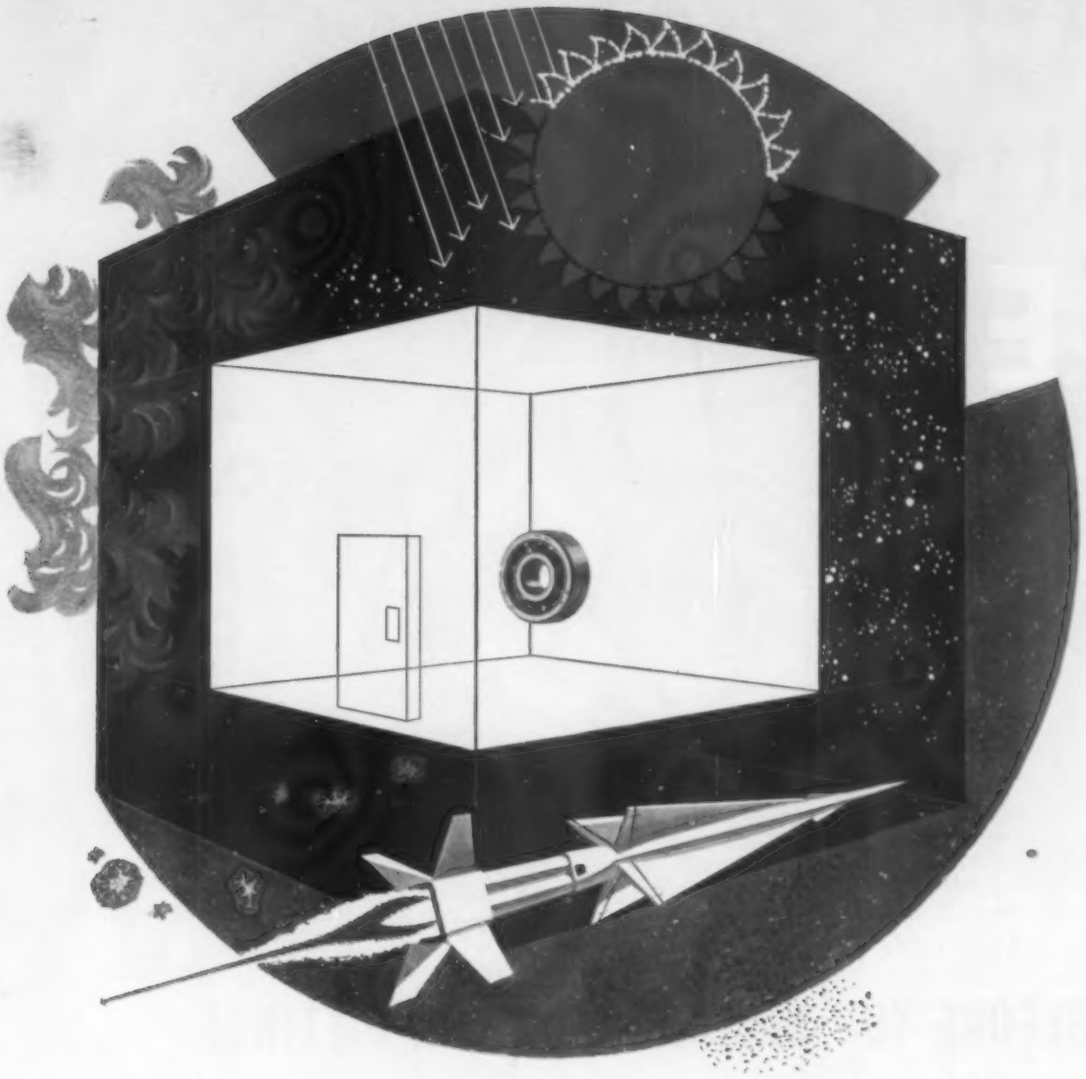

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tional Symposium on Combustion, Cal-Tech, Pasadena, Aug. 29-Sept. 2.

10th International Congress of Applied Mechanics, Congress Bldg., Stresa, Italy, Aug. 31-Sept. 7.

SEPTEMBER

13th General Assembly of the International Scientific Radio Union, University College, London, Sept. 5-15.

SOCIETY of British Aircraft Constructors Show and Flying Display, Farnborough, England, Sept. 6-11.

Electronics Industries Association, Second Conference on Value Engineering, Disneyland Hotel, Anaheim, Sept. 7-8.

Joint Automatic Control Conference, Mass. Institute of Technology, Cambridge, Sept. 7-9.

American Chemical Society, 138 National Meeting, New York, N.Y., Sept. 11-16.

Second International Congress in the Aeronautical Sciences, sponsored by the International Council of the Aeronautical Sciences, Zurich, Switzerland, Sept. 12-16.

IIIrd International Congress on Surface Activity, Cologne, Germany, Sept. 12-17.

Electronic Industries Association, Fall Conference, Sheraton-French Lick Hotel, French Lick, Ind., Sept. 13-16.

Engineering Management Conference, sponsored by American Institute of Electrical Engineers, and American Society of Mechanical Engineers, Morrison Hotel, Chicago, Sept. 14-16.

Armed Forces Chemical Association, 15th Annual Meeting, Sheraton Park Hotel, Washington, D.C., Sept. 15-16.

Institute of Radio Engineers, National Symposium on Space Electronics & Telemetry, Shoreham Hotel, Washington, D.C., Sept. 19-22.

ASME-AIEE Power Conference, Bellevue-Stratford Hotel, Philadelphia, Sept. 21-23.

Industrial Electronics Symposium, sponsored by Institute of Radio Engineers and American Institute of Electrical Engineers, Manger Hotel, Cleveland, Sept. 21-22.

Air Force Association, National Convention and Aerospace Panorama, San Francisco, Sept. 21-25.

American Ceramic Society, Electronics Division, Hotel Schroeder, Milwaukee, Sept. 22-23.

American Institute of Chemical Engineers, Mayo Hotel, Tulsa, Okla, Sept. 25-28.

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A possible Earth to Venus Trajectory (dotted line) for 107-day flight programmed for burnout conditions over Cape Canaveral on 16 January 1961 at 15.65 hours (ephemeris time). Illustration shows positions of Earth, Venus, vehicle at eighteen-day intervals.

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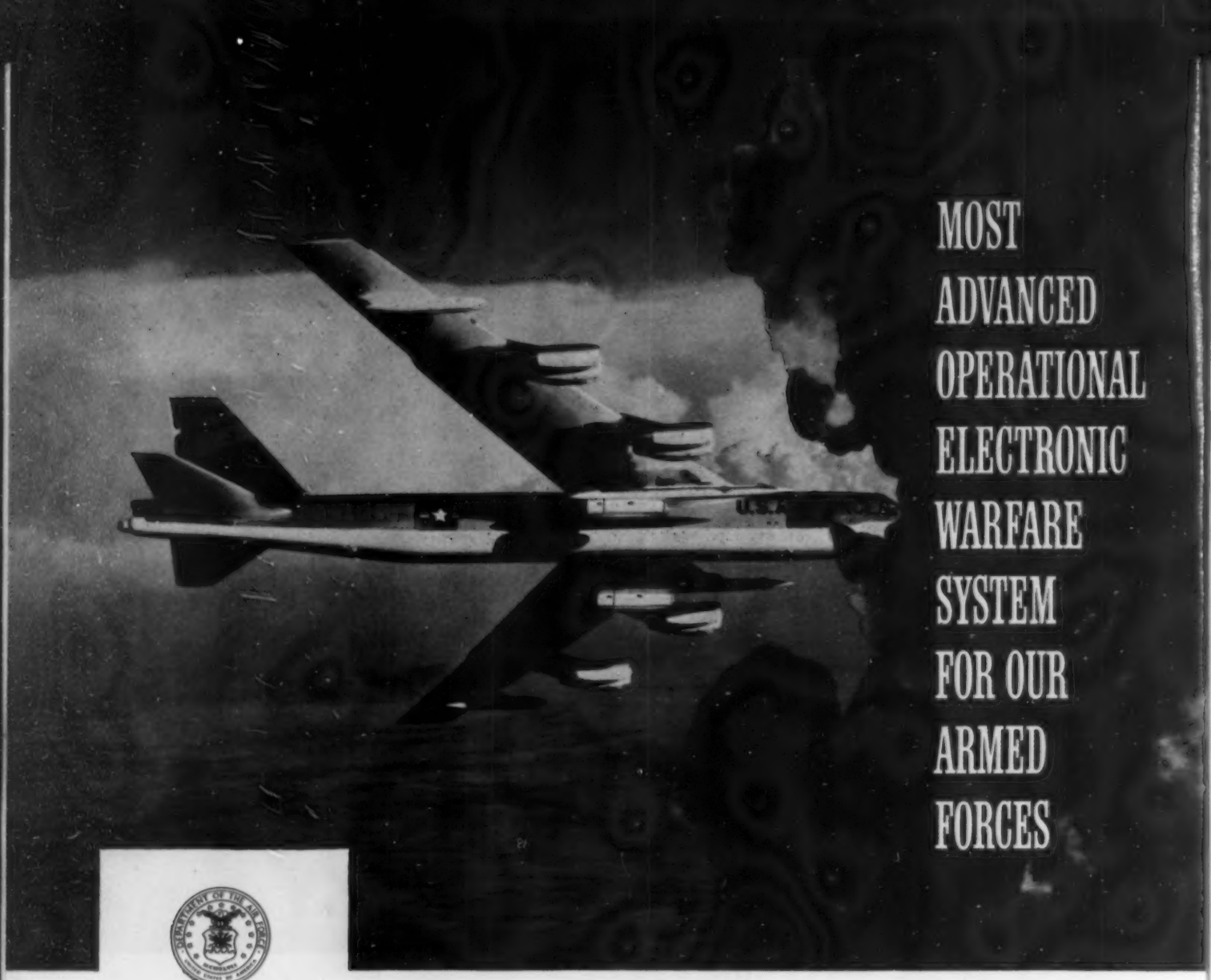

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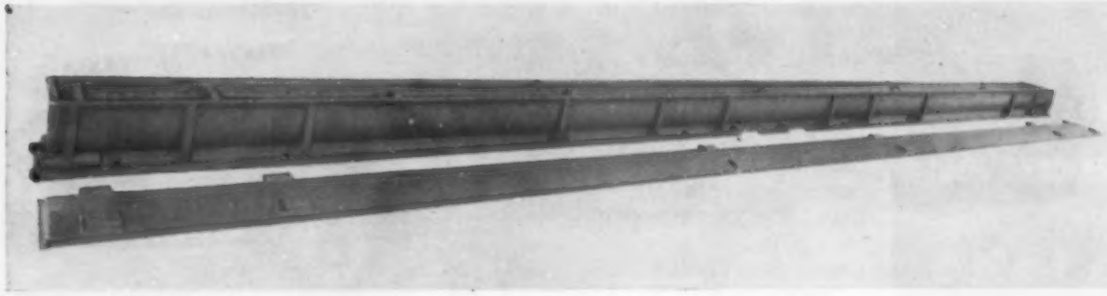

Forty-three-foot-long aluminum containers created by The Baltimore Steel Company for the periscopes for the Polaris missile submarine, the Skate, the Nautilus and other atomic submarines. The Baltimore Steel Company is the only company producing this type of container. Designed, built and tested under contract with the U.S. Navy Bureau of Ships.

In the important race through space, where national survival is increasingly dependent on the precision and accuracy of this nation's missiles and rockets, it is vitally necessary that these missiles be packed, stored and delivered in the proper containers. These containers must be able to withstand vigorous transportation stresses under all sorts of atmospheric conditions, without in the slightest degree affecting the missile and disturbing its highly sensitive instrumentation and electronic equipment.

The Baltimore Steel Company is very proud of its role as a pioneer and leader in designing, creating and producing containers for the Military Services and industrial concerns, exactly tailored to the individual requirements of each program. The Baltimore Steel Company has been a major factor in the successful development of containers for all types of aircraft engines, missiles, torpedos, and various ordnance items.

From assisting in the creation of the original design, and through every step to the delivery of the finished product, The Baltimore Steel Company is well equipped, through experience and know-how, and with the capacity and capability to handle all container requirements promptly, efficiently, economically.

Containers for components of these other missiles have been designed and produced by The Baltimore Steel Co.

- ●HAWK
- ●TERRIER
- ●POLARIS
- ●MACE
- ●CORPORAL
- ●TALOS
- ●MATADOR
- ●ASTOR
- ●GREBE-JATO

There is no substitute for experience and know-how. The Baltimore Steel Company has built tens of thousands of containers for reciprocating engines, turbo-props, jets, torpedos, transmissions for tanks, and other ordnance material . . . where absolute accuracy, precision and dependability are required. The Baltimore Steel Company is successfully meeting new challenges and problems brought to it regularly by American industry and the Military Services.

Container for Inertial Guidance Platform for the Redstone Missile. This complex container, custom built by The Baltimore Steel Company, is insulated and thermostatically controlled, to prevent exposure to low temperature.

For immediate assistance write or call:

Container Division

The Baltimore Steel Company

1400 Eastern Avenue, Baltimore 31, Md. • 501 North Point Road, Baltimore 6, Md.

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missile tracker for china lake

Kollmorgen Missile Tracking Binoculars are an integral part of an acquisition and photography system which records tactical air-to-air missile performance at China Lake Naval Ordnance Testing Station. These binoculars, adapted from a basic Kollmorgen design, are high magnification, wide-field instruments with unusual light-gathering power. An operator is able to spot a missile-launching aircraft and track the missile from the time it is fired until it finds its target—all at extreme ranges. Among other Kollmorgen contributions to the missiles field are the bunker periscopes at Cape Canaveral.

By combining optics, mechanics and frequently electronics, Kollmorgen designs many different types of instruments and systems for industrial and defense viewing and inspection applications. A new illustrated brochure describes our design and manufacturing facilities and primary fields of interest. For your copy, write Dept. 107.

KOLLMORGEN
optical corporation
NORTHAMPTON, MASSACHUSETTS

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mergers & expansions

BELL INTERCONTINENTAL CORP. which before the sale of its defense subsidiaries to Textron, Inc. was known as Bell Aircraft Corp., has elected James F. Connaughton president and chief executive officer. Admiral Robert B. Carney, (USN Ret.), former Chief of Naval Operations, has been named a director and chairman of the board. Herbert Brownell, former U.S. Attorney General now with Lord, Day and Lord, has been retained as special counsel.

COLLINS RADIO CO. recently broke ground for a 30,000-sq.-foot communications and data processing center in northeast Cedar Rapids, Iowa. The center will be used by all of Collins' divisions throughout the United States and Canada.

DORSETT ELECTRONICS LABS of Norman, Okla., has merged with Carter and Galantin, Inc. of Chicago, a firm which provides marketing programs for industry, including the manufacture of training and sales devices and films. Carter and Galantin will become a Dorsett division, but continue to operate its facilities in Chicago, New York and Atlanta under its own name. Dorsett produces airborne telemetering systems and audio-visual devices.

ARNOUX CORP. of Los Angeles has acquired Telemetrics, Inc., producers of simulators and signal converters. Robert L. Burr will be general manager of Telemetrics.

CONSOLIDATED ELECTRODYNAMICS CORP., Bell & Howell subsidiary, has established a Technical Supplies Dept. to market recording paper for oscillography, photographic chemicals for oscillogram processing, and magnetic tape for instrumentation. The department will make headquarters in Pasadena.

EMPIRE STATE LABS has been purchased by Helmuth W. Waldorf, former President and owner of the Waldorf Instrument Co., now a F. C. Huyck Corp. division. Waldorf assumes the position of president of the laboratories, which have been incorporated under the name Empire Flight Components, Inc.

RAMO-WOOLDRIDGE DIV. of TRW has opened a Northeastern District Office in Lexington, Mass. . . . J. M. Loge has been incorporated under the name Loge Electronics, Inc.

BARDEN CORP. has purchased a 50% stock interest in E.M.O. Instrumentation Ltd., British manufacturer of precision ball bearings . . . H. K. Porter Co. has acquired Acieries & Ateliers de Construction de Marpent,

(Continued on page 26)

THE PROBLEM: Development of a new, highly reliable rocket propulsion system

IN FINDING A SOLUTION:

2 HEADS ARE BETTER THAN 1

BUT ARE . . .

4 BETTER THAN 2?

8 BETTER THAN 4?

16 BETTER THAN 8?

32 BETTER THAN 16?

64 BETTER THAN 32?

128 BETTER THAN 64?

At United Technology Corporation, the old adage—"two heads are better than one"—is viewed with respect.

But it also is recognized that at some point, too many can cause excessive administrative detail, confusion, and red tape which increases the difficulty of finding the solution to the original technical problem.

The emphasis—corporate philosophy—at United Technology Corporation, therefore, is on quality—capacity of mind, talent and experience, rather than on sheer numbers of people. This approach permits the maximum percentage of scientific and engineering man-hours to be devoted to the analyses and experimentation required to obtain the best answers to the technical problems at hand.

UTC

UNITED TECHNOLOGY CORPORATION

A subsidiary of United Aircraft Corporation
P. O. Box 358 • Sunnyvale, Calif.

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W. M. Willis, Chief Engineer of Marman Division, displays some of the many couplings and joints developed by Marman engineers.

MARMAN

Leads in Joint and Coupling Engineering

Pictured at the left are a few of the many V-Band Couplings and Joints designed and produced by Marman for every aircraft and missile application. Marman V-Band Couplings are ideal for connecting all sizes of tubing, piping and ducting used in fluid transfer and structural applications. The lightweight Marman J13 V-Band Joint provides efficient sealing for pneumatic and hot air or gas lines. The J11 V-Band Joint may be used for fluid systems. Marman high-performance CONOSEAL Joints provide a leakproof seal where zero leakage is required over a wide temperature range.

Call on Marman's 20 years of experience when you have a joint or coupling problem. Highly skilled and experienced engineers are ready to be of assistance to you. Also send for the new Marman Catalog No. 800 showing hundreds of joints available from stock.

CONOSEAL is an Aeroquip Trademark

Aeroquip
MARMAN DIVISION

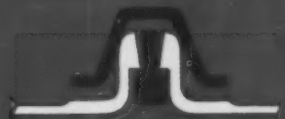
11214 Exposition Blvd., Los Angeles 64, California

Joints, V-Band Couplings and Flanges, Fuel and Hot Air Couplings, Band Clamps, Instrument Clamps, Bellows, Ducting, and Universal Joints.

A WIDE PERFORMANCE RANGE IS POSSIBLE THROUGH DIFFERENT FLANGE AND GASKET DESIGNS AS ILLUSTRATED

Standard V-Band Couplings and flanges for high-strength structural connection of components and tubing, choice of solid or formed flanges.

J13 Joints provide a lightweight connection for standard and thin wall tubing where low leakage rate is permissible.



J11 Joints for fluid connections where zero leakage is not required, as well as hot air and gas lines for temperatures up to 1000° F., pressures to 4000 psig.

CONOSEAL Joints provide zero-leakage connection of tubing and piping over temperature range of —423° F. to +2900° F., pressures to 20,000 psig.

for an extension in Reliability

engineered...

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SINGLE RESPONSIBILITY FOR PERFORMANCE OF PLUG/HARNESS SYSTEMS...RELIABILITY GUARANTEED!

- CANNON PLUG/HARNESS SYSTEMS are designed and manufactured under rigid, quality-controlled conditions in a separate, highly specialized facility completely equipped to handle all phases of design, development and manufacture. As a single source supplier for both plugs and harness assemblies, Cannon can assume complete responsibility for the reliability of the "Cannon Plug/Harness System" as a whole.

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- SPECIAL DESIGN SERVICES: Because Cannon is a single source supplier of the plugs and completes the termination, it is possible to select and recommend cables and termination techniques designed to custom-match the proper plug for the assembly. The complete assembly can thus be manufactured and tested under conditions prohibited to single-source suppliers.

- FASTER DELIVERY – NO COST PYRAMIDING: A special, separate facility devoted to umbilical and harnessing production offers the most up-to-date production techniques to provide the industry's fastest delivery—plus no pyramiding of costs. Customers draw on Cannon's capabilities as the world's largest exclusive manufacturer of electrical plugs.

- FIELD TECHNICAL ASSISTANCE: Experienced specialized sales engineers are available to discuss and assist customers in the technical aspects of plug-harness system requirements prior to manufacture and after installation in the field.

CANNON PLUG/HARNESS SYSTEMS ARE MANUFACTURED IN OUR PHOENIX, ARIZONA FACILITY

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LOS ANGELES 31, CALIF.

CANNON PLUGS

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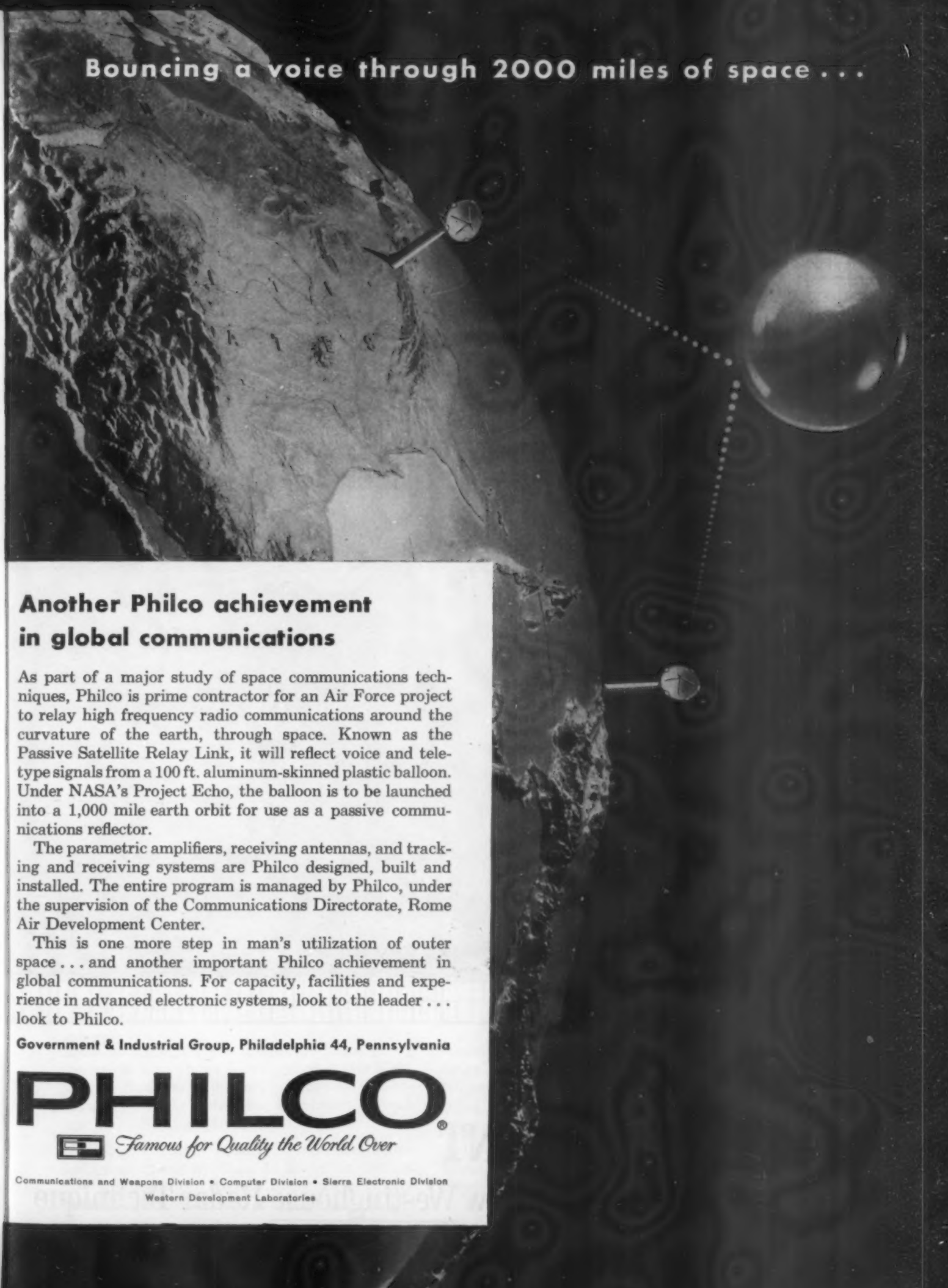

Another Philco achievement in global communications

As part of a major study of space communications techniques, Philco is prime contractor for an Air Force project to relay high frequency radio communications around the curvature of the earth, through space. Known as the Passive Satellite Relay Link, it will reflect voice and teletype signals from a 100 ft. aluminum-skinned plastic balloon. Under NASA's Project Echo, the balloon is to be launched into a 1,000 mile earth orbit for use as a passive communications reflector.

The parametric amplifiers, receiving antennas, and tracking and receiving systems are Philco designed, built and installed. The entire program is managed by Philco, under the supervision of the Communications Directorate, Rome Air Development Center.

This is one more step in man's utilization of outer space . . . and another important Philco achievement in global communications. For capacity, facilities and experience in advanced electronic systems, look to the leader . . . look to Philco.

Government & Industrial Group, Philadelphia 44, Pennsylvania

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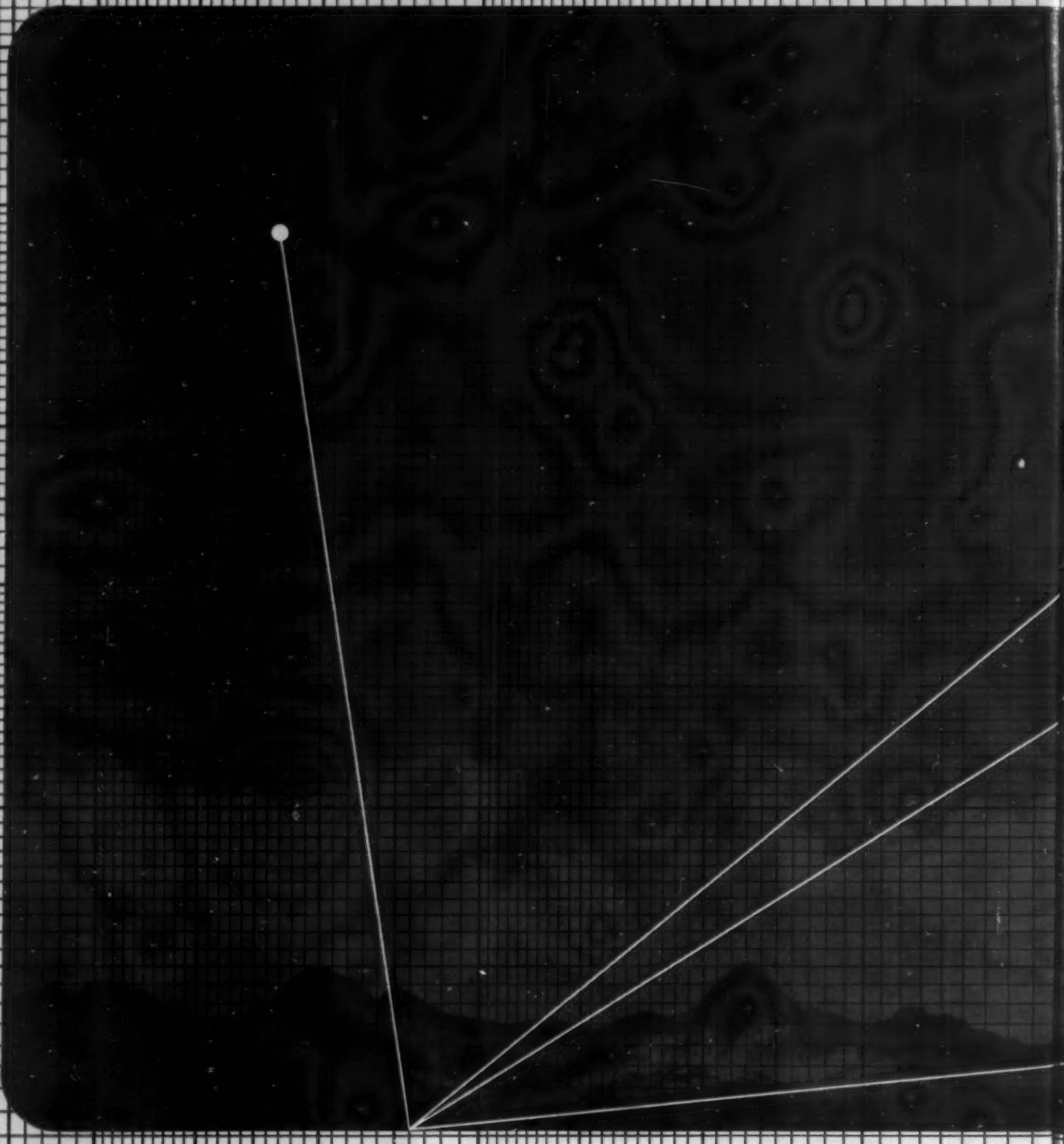
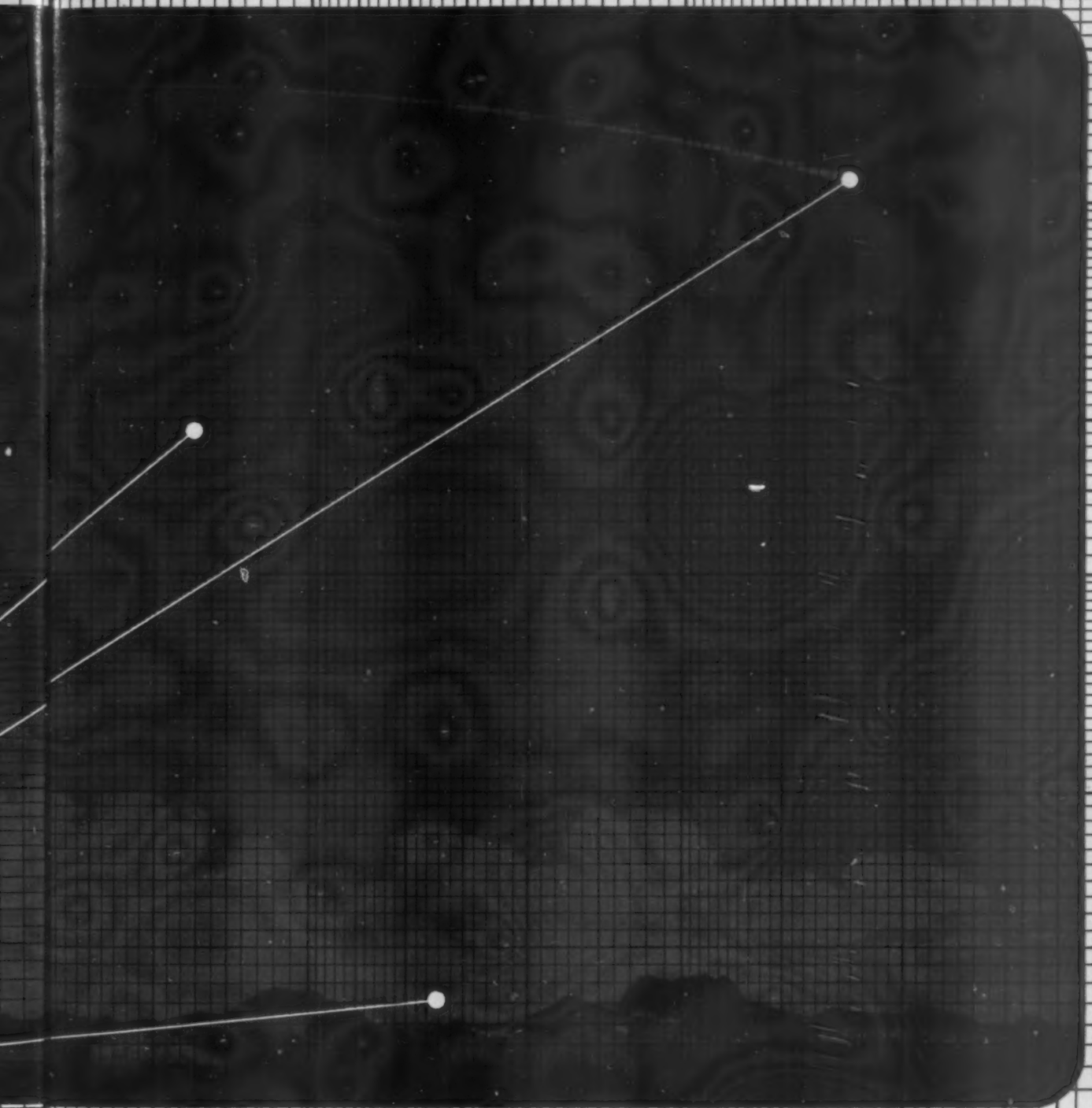


PRECISE MEASUREMENT IN SPACE... with New Westinghouse Radar Technique



An entirely new Westinghouse radar technique now under development at the Electronics Division will sharply increase the accuracy of radar detection, identification and tracking of objects in space.

Utilizing a single radar, the Westinghouse technique opens the door to many important new applications. Among them are accurate measurement of objects in space, satellite reconnaissance, air-to-ground surveillance and mapping and ground-to-air tracking and identification.

We would be pleased to discuss these new developments with qualified persons on a classified, need-to-know basis. Contact: Marketing Manager, Electronics Division, Westinghouse Electric Corporation, Baltimore, Maryland.

YOU CAN BE SURE... IF IT'S **Westinghouse**

Circle No. 20 on Subscriber Service Card.

letters

The Law's Injustice

To the Editor:

Your article on "The Renegotiation Mess" in the July 4 issue of M/R is most interesting and certainly provides a considerable amount of enlightening information.

But there is one facet of Renegotiation which was not mentioned. This is the portion of the law which pertains to manufacturers' representatives.

There are many points about this section of the law which are most unfair to the bona fide manufacturers' representative, the corrections for which are long overdue.

Over the years the minimum reporting amount for manufacturers has been increased, until this amount is four times that contained in the original law. The amount for manufacturers' representatives' reporting has not been changed at all.

Probably the most unfair portion is that (the fees of) manufacturers' representatives alone have been singled out from all of the consultants, professional people, and other independent contractors, and are separately renegotiated, rather than being renegotiated through the manufacturer.

Other provisions of this law make it possible for a manufacturers' representative's fees to be renegotiated even though none of the companies he represents is covered.

When any changes in the Renegotiation Act are considered by Congress, as they supposedly will be by this House committee, the matter of its application to manufacturers' representatives should be given fair and impartial consideration.

Kenneth E. Hughes
Union City, N.J.

First Drone Directory

To the Editor:

I would be very grateful if you would please send me a reprint of the Directory of U.S. Aerial Targets and Combat Surveillance Drones which appeared in the June 27 M/R. To my knowledge this is the first time anyone has compiled such a directory. Congratulations on a remarkable job.

Leonard Matula
Chicago

Misleading Title

To the Editor:

I would like to comment on my article in the April 18 M/R which you entitled "How to Propose a Research Program." As submitted, the title was, "A Philosophy for Propellant Research" . . .

While the article does tie in with research proposals, it was concerned primarily with the establishment of criteria for determining the validity of a research approach. Obviously, it did not provide an adequate treatment of the subject, "How to Propose a Research Program," since this was not its intent.

Charles N. Bernstein
Group Scientist, Propellants and Polymers
Rocketdyne Division, North American Aviation, Inc.
Canoga Park, Calif.

Bad Siting at Tucson?

To the Editor:

Enclosed are some further press stories and other items bearing on our local protest against Air Force siting policies (M/R, June 13, page 17). The sites of

WHITTAKER CONTROLS
PLANNED RELIABILITY
is important in the Discoverer Satellite Program
WHITTAKER RELIEF VALVES... control individual propellant tank pressures, differential tank pressures and provides tank dump feature.
Planned Reliability is important to the success of the Discoverer Satellite Program. When the Thor-Agena launch vehicle thunders off the pad toward orbit position for the second stage, valves and fluid control systems must function with predetermined accuracy to assure successful positioning and stabilization of the satellite.
The wide acceptance of Whittaker Controls Products for the most difficult and exacting applications is the result of design integrity and precise adherence to sound engineering and manufacturing principles.
Advanced design concepts, environmental testing and quality-controlled production . . . assure you of Planned Reliability in every valve and fluid control system that bears the famous Whittaker name!
Advanced concepts now being planned at Whittaker Controls present unusual and challenging opportunities for qualified engineers. Why not inquire now?

the first nine of Tucson's 18 *Titans* were publicly announced on June 8. They insure 100% certainty that lethal fallout from enemy attack will hit Tucson should war come. All escape routes out of the city will be destroyed because the policy is to build these sites right beside good highways and Tucson has only five highways leading through the surrounding mountains. Tucson will become the *worst-sited* of all the *Atlas* and *Titan* bases in the country if something is not done to forestall use of the announced site locations.

We are appealing for Congressional investigation of the entire policy with respect to fixed-base ICBM's . . . We hope that you may take note of this step in our protest by reporting it in M/R. We were very pleased to see the earlier note you ran on this issue.

J. E. McDonald, Chairman
Committee Against Ringing
Tucson With Titans
Tucson, Ariz.

FDR to Blame?

To the Editor:

It certainly would be a pity if this otherwise excellent technical publication should degenerate into a political digest.

Your discussion (M/R, June 6) of the so-called public relations "Fiasco", and especially the thinly veiled attack upon the Vice President of the United States, is unnecessary and ill-advised.

If this editorial is politically inspired it can be deflated easily: Our country is in this predicament thanks to F.D.R. and H.S.T. and their give-away policies in Yalta and Potsdam.

Who, in his right mind, could trust a donkey-riding crusader, waving a defeatist banner and galloping toward ultimate disaster?

A. J. Jankunas
Engineer
Cicero, Ill.

Cheap Fuel Suggestion

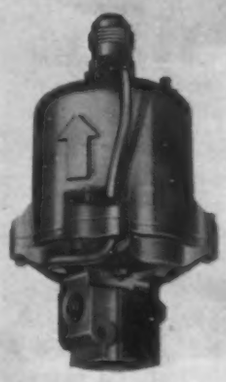
To the Editor:

In a recent Soviet Affairs section, Dr. Parry quotes a Russian scientist as having said that ". . . Pacific Ocean hurricanes roar incessantly, with winds reaching 30 to 35 miles per second."

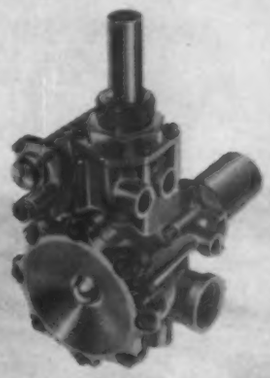
Could it be that we have missed out on something? With a wind velocity of this magnitude, 126,000 miles per hour, we may no longer need to provide a powerplant for our space shots. We can simply place a missile into the wind, guide it correctly, and the Pacific hurricane will carry it off into space. What a weight saving!

Charles O. Heller
Santa Monica, Calif.

It was a typographical error which we are still trying to figure out.—Ed.



WHITTAKER REGULATOR . . .
Controls pressure on propellant tanks for expulsion of fuel and oxidizer to engines.



WHITTAKER PRESSURE REGULATOR . . .
programmed for future missile use, is gold plated for balance of solar radiation . . . regulates gas pressure to nozzle valves in vernier control system.

• *Write for your copy of the Whittaker Controls engineering, testing and production Capabilities Brochure.*

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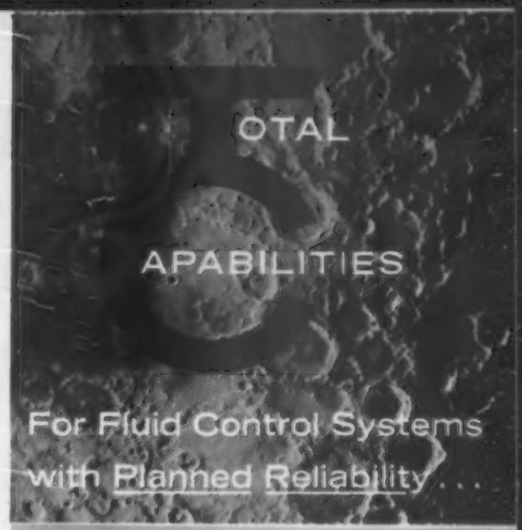

WC — **WHITTAKER CONTROLS:** Designs and produces fluid control systems, subsystems and components for military and commercial aircraft and missiles.

NI — **NARMCO INDUSTRIES:** Specializing in research and manufacturing in the field of lightweight, high-strength structural components and materials for a variety of Military and Industrial applications.

WG — **WHITTAKER GYRO:** Leading designer and manufacturer of precision gyroscopes, accelerometers, guidance and control systems.

MA — **MONROVIA AVIATION:** Producers of precision aircraft structural assemblies and portable air conditioning units for ground support.

TSI — **TELECOMPUTING SERVICES, INC.:** Specialists in data processing and data systems engineering.

ES — **ELECTRONIC SYSTEMS:** Specialists in systems management, and in the design and manufacture of complex electronic and nucleonic equipment for Government and industry.

DI — **DATA INSTRUMENTS:** Leading designer and producer of data reduction systems, industrial control and ground support equipment.

CB — **COOK BATTERIES:** Designers and manufacturers of automatically and manually activated silver zinc batteries for missile applications.

EC — **ELECTRONIC COMPONENTS:** Designers and producers of miniature relays, sub-miniature ceramic capacitors, magnetic amplifiers, transformers and delay lines.

PE — **PHOENIX ENGINEERING:** Manufacturer and assembler of precision machined missile, aircraft and electronic parts.

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. . . mergers & expansions

(Continued from page 18)

French producer of steel, railway cars and industrial products . . . Bendix Corp. has purchased a controlling interest in Diseradores y Constructores, S.A., one of Mexico's leading tool-and-die firms.

ATLANTIC RESEARCH CORP. has begun work on a $1.5 million addition to its facilities at Alexandria, Va. The 120,000-sq.-ft. building will be connected to the original plant by an overhead walkway.

GIANNINI SCIENTIFIC has purchased Wiley Electronics Co. of Phoenix, Ariz., formerly a subsidiary of Savage Industries. Giannini, which already numbers Plasmadyne, Plasmakote and Flight Research among its subsidiary corporations, is negotiating for further mergers with as yet unnamed companies.

PYROFUZE CORP. has been organized by the Sigmund Cohn Corp., of Mount Vernon, N. Y. The firm will manufacture specially processed Pyroforic Products, a bi-metallic product that disintegrates with explosive violence at 600°C without support of oxygen.

financial news

Aerojet General Corp.—Consolidated sales reached $200.5 million for the six months ended May 31, an increase of 29% over the same period last year. Earnings were up 16% from $3.8 million to $4.5 million.

Digitronics Corp.—Sales for the fiscal year ended March 31 totaled $822,000, a 50% increase over the $553,000 reported for FY 1959. Net income for 1960 amounted to $35,652, compared to $23,618 for the previous year.

Sanders Associates, Inc.—New business in excess of $30 million raises Sanders' backlog to $50 million. President Royden Sanders said the firm expects total sales for the year ending July 31 to reach $17 million; he forecasts a 50% rise next year.

Infrared Industries—Record sales reached $1.8 million, an increase of 50% over FY 1959, and net earnings increased 28% to $122,207.

Wilson Bros.—Sales for the first five months of this year jumped 72% to $14.9 million, compared to $8.6 million for the same period last year. The firm expects sales of about $38 million for 1960.

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The sure dependability of DIMAZINE has been convincingly demonstrated in many ways and under a wide variety of ground and flight conditions.

DIMAZINE provides fast, dependable hypergolic starts followed by smooth, stable combustion and easier shutdowns. Dependable instant readiness is assured for years by its outstanding stability during storage in sealed missile tankage. You can also depend on DIMAZINE's high chemical purity and uniformity, high thermal stability, low freezing point, low shock sensitivity, minimum susceptibility to contamination and high compatibility with almost all metals and appropriate sealing materials.

These manifold advantages combine to make DIMAZINE *the outstanding storable fuel.* We will be pleased to work with you in evaluating DIMAZINE and to supply detailed data on its properties and handling.

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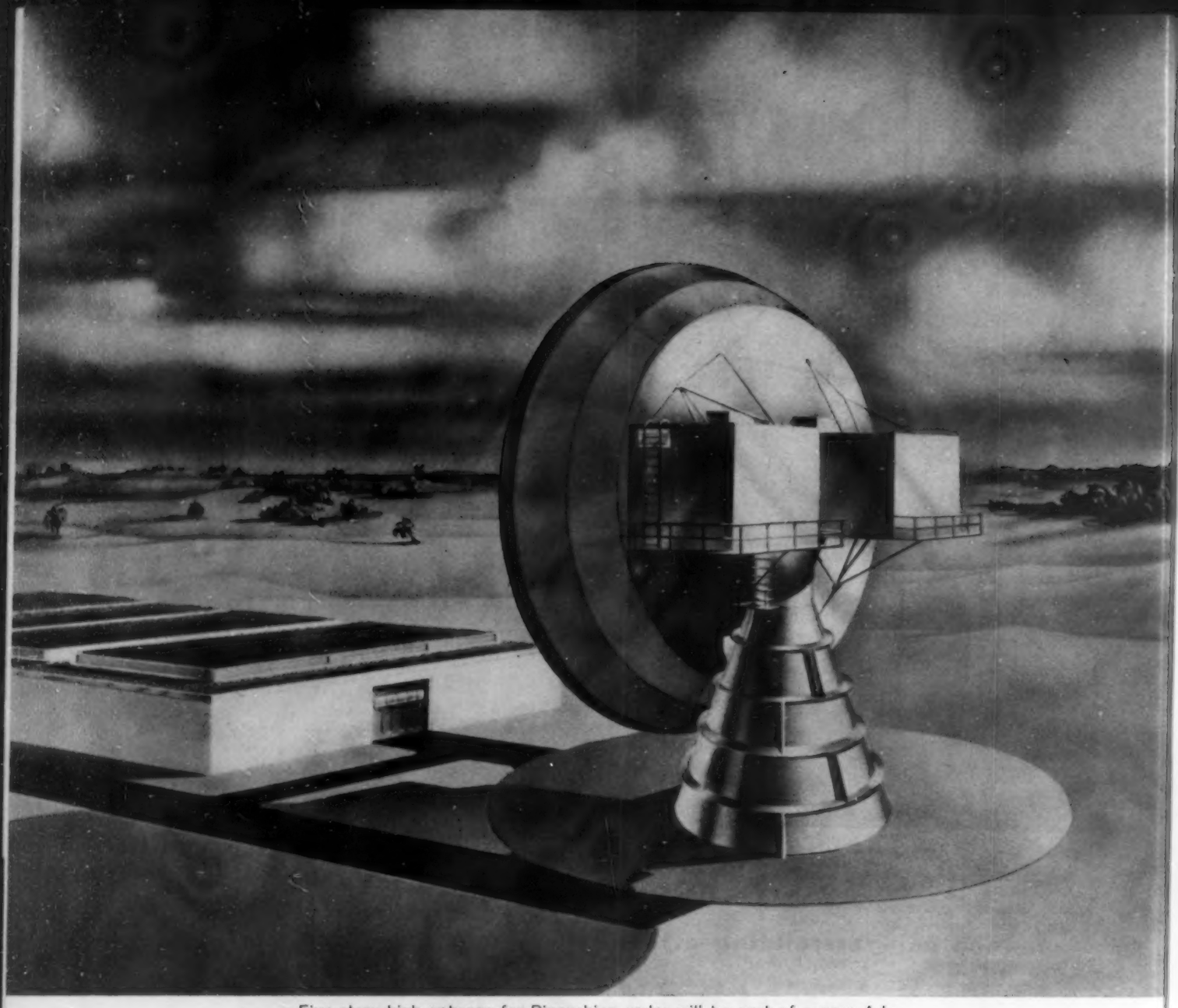

Five-story high antenna for Pincushion radar will be part of a new Advanced Research Projects Agency installation to be set up in mid-Pacific.

A unique radar designed to track and identify the warhead of ICBMs thousands of miles away is now being developed by Raytheon.

Designated "Pincushion", because of its microwave beam pattern formation, the 80-ton Raytheon radar will be part of Project Defender, ARPA's program to develop advanced anti-ICBM concepts.

RAYTHEON COMPANY, WALTHAM, MASS.

RAYTHEON

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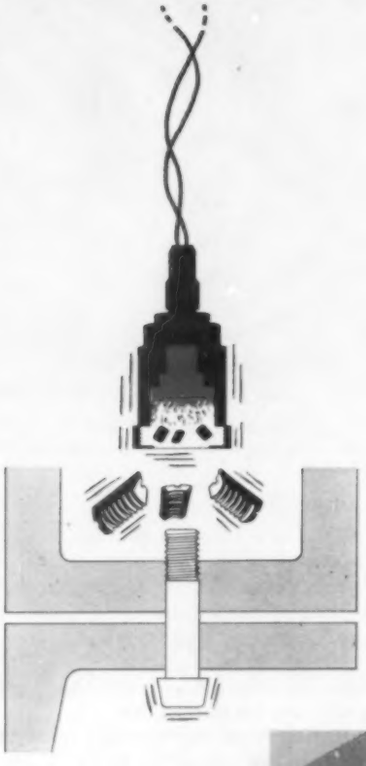
- SEPARATION OF MULTI-STAGE VEHICLES AND NOSE CONES.
- RELEASE FROM LAUNCHING PADS.
- RELEASE OF BOOST ROCKETS AND LAUNCHING SLEDS.
- RELEASE OF TANKS AND JETTISONABLE ITEMS.

FOR SEPARATION SYSTEMS

THE NEW

SEPARATION NUT



A unique, safer and more efficient method for separation systems is offered by the Separation Nut.

The Separation Nut is unique because its controlled separation is a highly reliable mechanical function activated by a very small explosive charge.

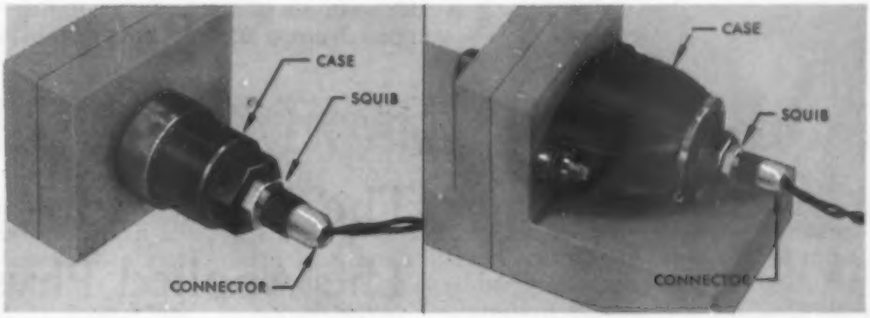
By using the Nut's small explosive charge rather than the "brute force" explosive techniques so commonly used to fail high strength material in explosive bolts, the Separation Nut can substantially reduce a potentially hazardous condition to installation crews and to the vehicle itself.

More compact joints can be designed since Separation Nuts are used in combination with standard diameter, high strength bolts used at full allowables.

Separation Nuts reflect another new fastening concept developed in Hi-Shear's specialized engineering and laboratory test facilities for the specific needs of space vehicles and high performance aircraft.

Write for brochure . . . describes how the Nut works, high speed photos, design goals, typical applications and summary of the test program.

PATENT APPLIED FOR.



NON-CAPTIVE NUT

Basic configuration . . . accommodates bolt thread sizes including ¼-28 thru ¾-16.

CAPTIVE NUT

Because only a few explosive charge is used, all fragments can be easily contained by Nut's case. A similar case can arrest a bolt after detonation.

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Scientific Freedom at APL

APL scientists Drs. G. Weiffenbach and W. H. Guier, originators of the fundamental concept that led to Project Transit, the navigational satellite program sponsored by the U. S. Navy.

Project Transit—the first of its satellites already is orbiting the earth—was sparked by the side-interests of physicists at the Applied Physics Laboratory less than three years ago. The Project, an important contribution to the science of navigation, was kindled because of the Laboratory's policy of encouraging its scientists free rein in exploring tangential thoughts.

Scientists and engineers seeking a favorable atmosphere for creative accomplishment are invited to associate with a resourceful research group at APL. Direct your inquiry to—

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The X-15 project is a truly national research effort by the Air Force, Navy, and National Aeronautics and Space Agency. In manned flight, the X-15 will scorch through uncharted skies at speeds of more than 4,000 miles an hour.

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From an original painting for CECO by R. T. Handville

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Products, too, are "known by the company they keep", and CECO is proud to be airborne with an array of important missiles as well as with many of the latest and finest military and commercial aircraft.

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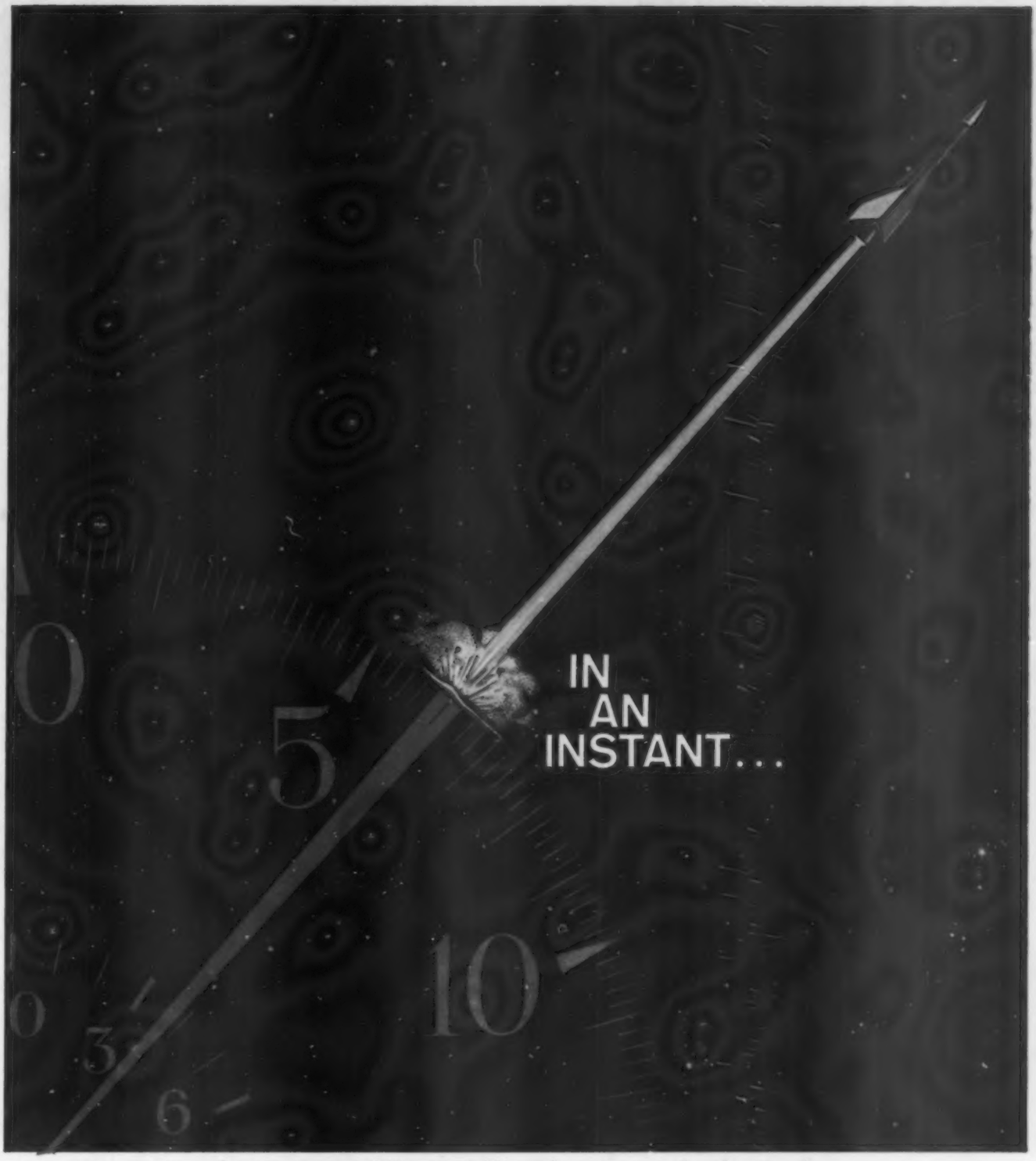

because this oxidizer's stored aboard

Nitrogen Tetroxide provides immediate, hypergolic ignition with amine fuels. Even after 9 years of storage, nitrogen tetroxide is ready for instant use. Combustion efficiencies closely approach the theoretical 99%.

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We'll gladly supply technical literature, including: a 59-page Product Bulletin, and a brochure entitled "Large Scale Handling of Nitrogen Tetroxide."

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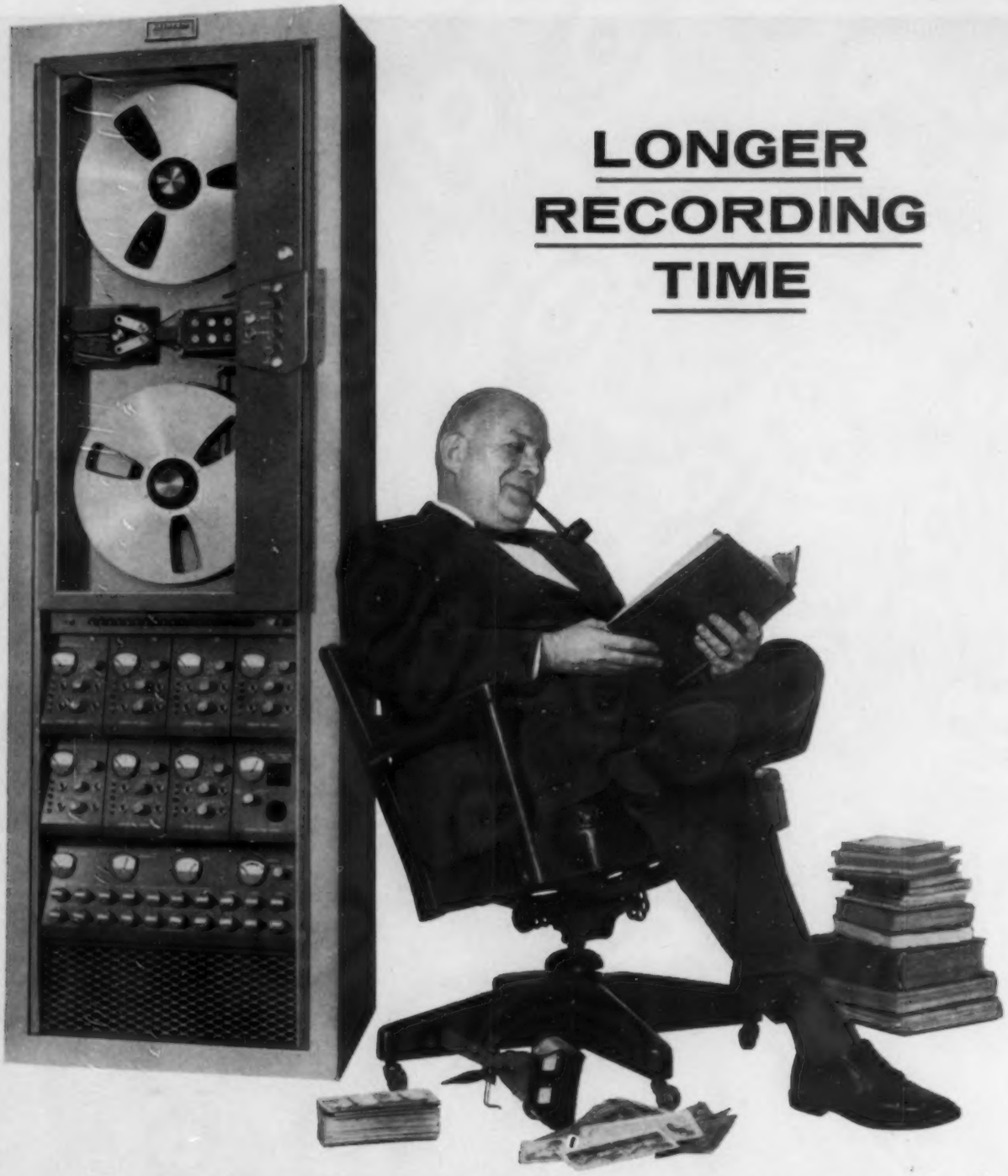

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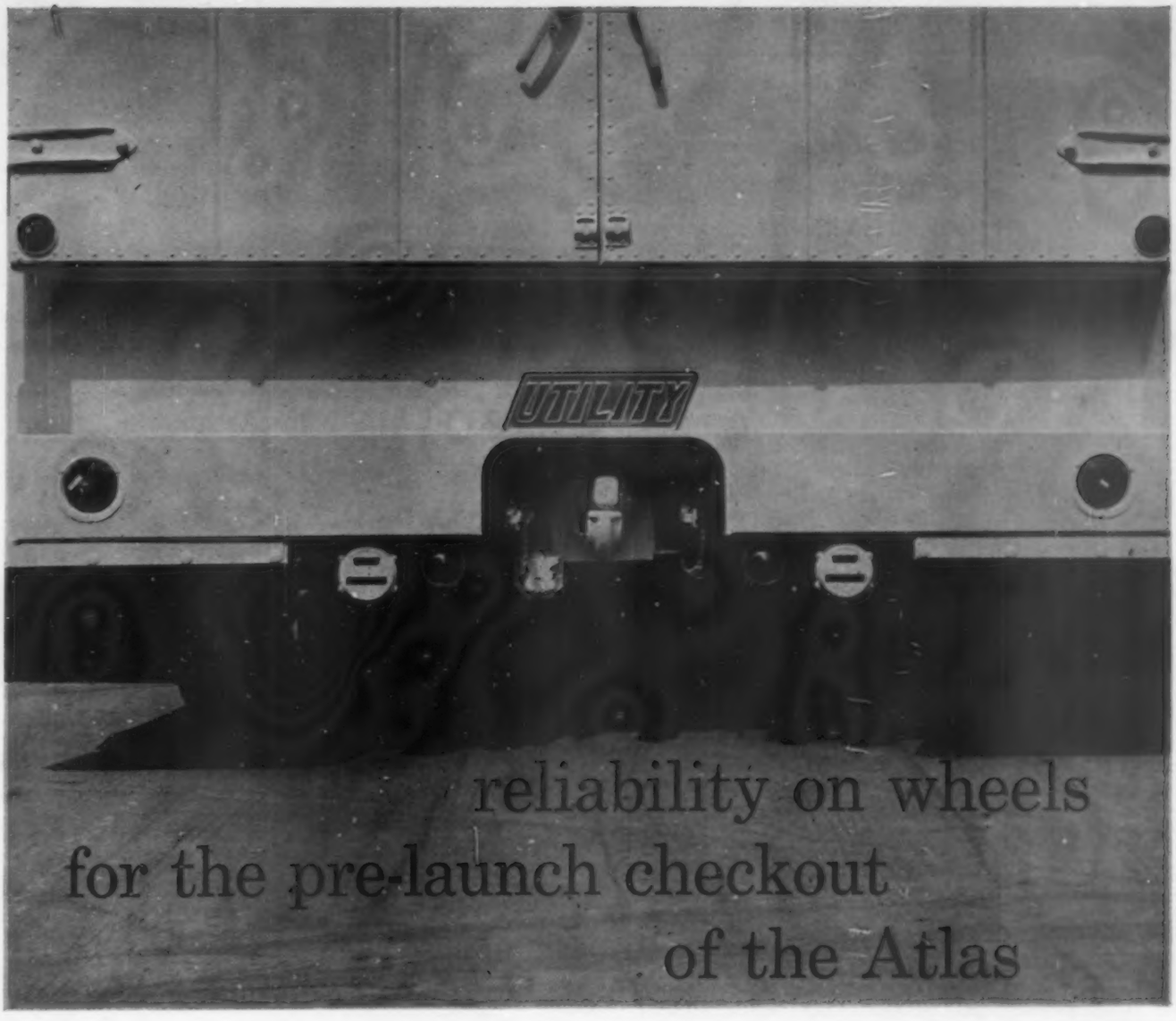
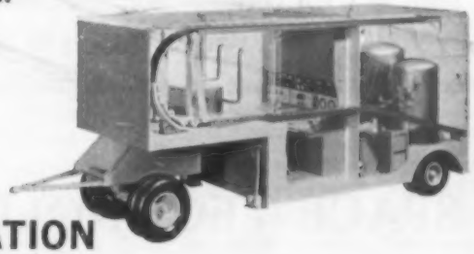


CV-A Part No. 27-08239-1 is another way of saying accurate, reliable ground support equipment—mounted on a trailer for mobility. Designed for Convair-Astronautics, this CSC system is used in the pre-launch checkout program for the Atlas missile. Packaged in a standard-size, highway semi-trailer, the pneumatic, dynamic system provides all necessary manual and automatic controls and an air-conditioned control room for operating personnel. Repeatability and reliability were the most important design criteria for the system, which is fully described in CSC Bulletin 3025-X2.



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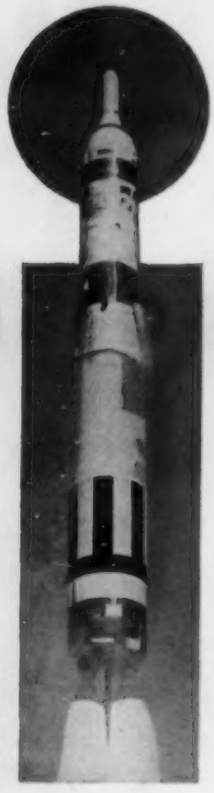
Another USAF missile
develops from a program
which is in itself a...

titan



Titan, America's two-stage intercontinental ballistic missile, is making giant strides—attaining new goals in U.S. missile technology. It has repeatedly demonstrated its ability to accomplish stage separation and altitude start of the sustainer engine. Equally outstanding successes in guidance and nose cone ejection-recovery are making Titan a significant contribution to our national space potential; a highly sophisticated missile system powerful enough to deliver a warhead accurately at more than 5,500-mile range.

As Titan continues to develop toward a state of operational capability, it provides another demonstration of the remarkable successes of the U.S. Air Force's ballistic missile program. This program, conceived only six years ago, has produced progress beyond expectation in an undertaking never before equalled in complexity.

Space Technology Laboratories is responsible for over-all systems engineering and technical direction for Titan, as it has been for Thor, Atlas, Minuteman and related space programs. Principal associate contractors for Titan include: The Martin Company for airframe and system integration, Avco Manufacturing Corporation for nose cone, Bell Telephone Laboratories and Remington-Rand for guidance, Aerojet-General Corporation for propulsion.

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The Countdown

WASHINGTON

A Ship Becalmed

Strong winds blowing out of the Democratic convention for greater defense spending are leaving the Eisenhower Administration unmoved. COUNTDOWN is told the Administration has all but decided to stand firm on its earlier refusal to use the extra half-billion dollars Congress tacked on the defense budget for missiles and space. There are reports, however, that some extra dollars may be released for the missile-packing B-70 bomber. How much, no one will say.

Undersea Revolution

Navy planners are eyeing the Reynolds Metal Co. Aluminaut—an experimental submarine designed to go down 15,000 ft. Now entering the construction phase, the Aluminaut could revolutionize undersea warfare. Made of high-strength aluminum alloy six inches thick, the sub will be roughly 33 ft. long, have an inside diameter of 7 ft. and be capable of carrying a 3-man crew 100 miles. Endurance of its silver-zinc storage batteries will be two days. Designed for oceanographic exploration, the sub would be able to outdive all known submarines by several thousand feet.

Almost Operational

The most potent air-to-air missile to be developed in years—the nuclear-tipped *GAR-11*—is now scheduled to be in Air Force squadrons by the end of this year. Made by Hughes Aircraft, *GAR-11* is the big brother of the *Falcon* missile family.

On the Pad

October 1 is the latest date to be set for the launching by NASA of an *Atlas-Able* with a $5 million moon-orbit payload. . . . Next shot in the *Mercury* program—possibly by the end of July—will be a test of the McDonnell production capsule atop an *Atlas*.

Courier Shot Slips

Launch of the Army Signal Corps' *Courier* delayed-repeater communications satellite—originally set for July 15—is expected to slip about a month. The reason: congestion at the pad.

INDUSTRY

AF Project 3059 to Aerojet

Aerojet-General has won the hot competition for the Air Force's Project *3059*—the development of a million-pound-thrust solid-propellant booster. Grand Central Rocket Co. has won a smaller, supporting contract to pursue a related approach on the giant, segmented motor. The Aerojet contract for FY '61 is for about $4 million. Size of the GCR award has yet to be established—but it will be for considerably less.

On Mahogany Row

Joining Northrop Corp. this week as a senior v.p. in charge of the company's research and advanced technology is Richard E. Horner, 42, associate administrator of NASA. Horner, who had held the NASA post 15 months, made his departure plans known some time ago (M/R, April 11). . . . W. R. Studhalter is Rocketdyne's new program manager on the J-2 200,000-lb.-thrust liquid hydrogen engine for *Saturn*.

Tops in '59

General Dynamics Corp. topped the nation's defense contractors in 1959 with contract awards totalling $1.5 billion. Boeing—the 1958 leader—was second with $1.2 billion. General Electric dropped from third to fifth place ($915 million), while Lockheed ($932 million) and North American ($925 million) each advanced one position—to third and fourth places respectively.

INTERNATIONAL

Polaris for NATO

The United States is now pushing hard a plan to arm NATO with 300 *Polaris* missiles. Britain and West Germany are expected to go along. However, Scandinavian countries are cool to the idea and France wants control over the nuclear warheads as the price for accepting them on French soil.

Bouillabaisse of Missile Deals

- Aerojet-General and SNECMA (France) have entered into an agreement calling for development work on an IRBM.
- French and German anti-tank missile competitors —Nord and Boelkow—have worked out a joint agreement on a new type of missile. Details are secret.
- SEPR (France) has just revealed details of its agreement with Rocketdyne (COUNTDOWN July 11, July 4) as involving the sale of small liquid-fueled rockets in the U.S. and in Europe, Turkey and Iran. SEPR is also tying up on joint development of new solid fuels with Bombrini Parodi-Delfine (Italy).

New French Missile

Sud Aviation *SE 4400* surface-to-air missile has been dropped by the military and in its place a new, secret version is being developed which will be both faster and have a longer range. The *SE 4400* may be incorporated into some French space experiments.

Jolly Comment from Abroad

A recent issue of *Flight* magazine, a British publication, displays a picture of an upended *Seaslug* missile being sprayed with water. The caption reads: "Environmental test, British style. Were this an American missile, the test concerned—which is to prove Seaslug's impermeability to driving rain—would be in a specially built million-dollar test facility with a name like TWERPS (Test Water Environmental Rain Proofing System). We British just hoist the thing up with a crane borrowed from the plant department, call out the works' fire brigade, and let them have a jolly good squirt."

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REDUCED PORTS stepped down three or more sizes interchangeable in all models.

MINIMUM CV available of .000001.

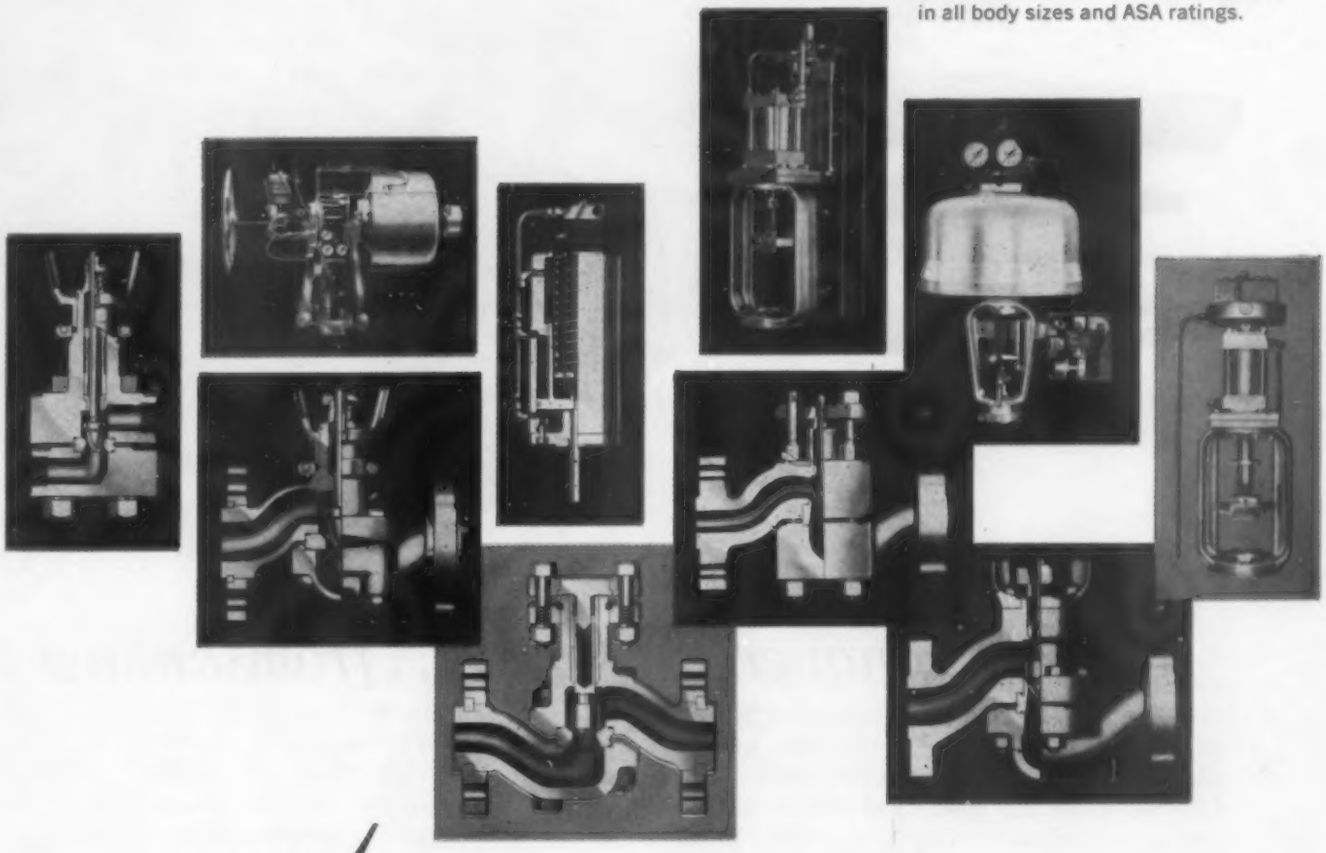
NO EXTRA CHARGE for reduced ports in any model 1 inch and under.

SOFT SEAT construction for guaranteed bubble tight shut off available in all models at minimum cost.

WIDE CHOICE of special body gasketing for all applications within temperature-pressure limitations of any valve.

TEFLON CHEVRON packing standard on all valves. Other types on request.

SPLIT BODY CHECK VALVE available in all body sizes and ASA ratings.



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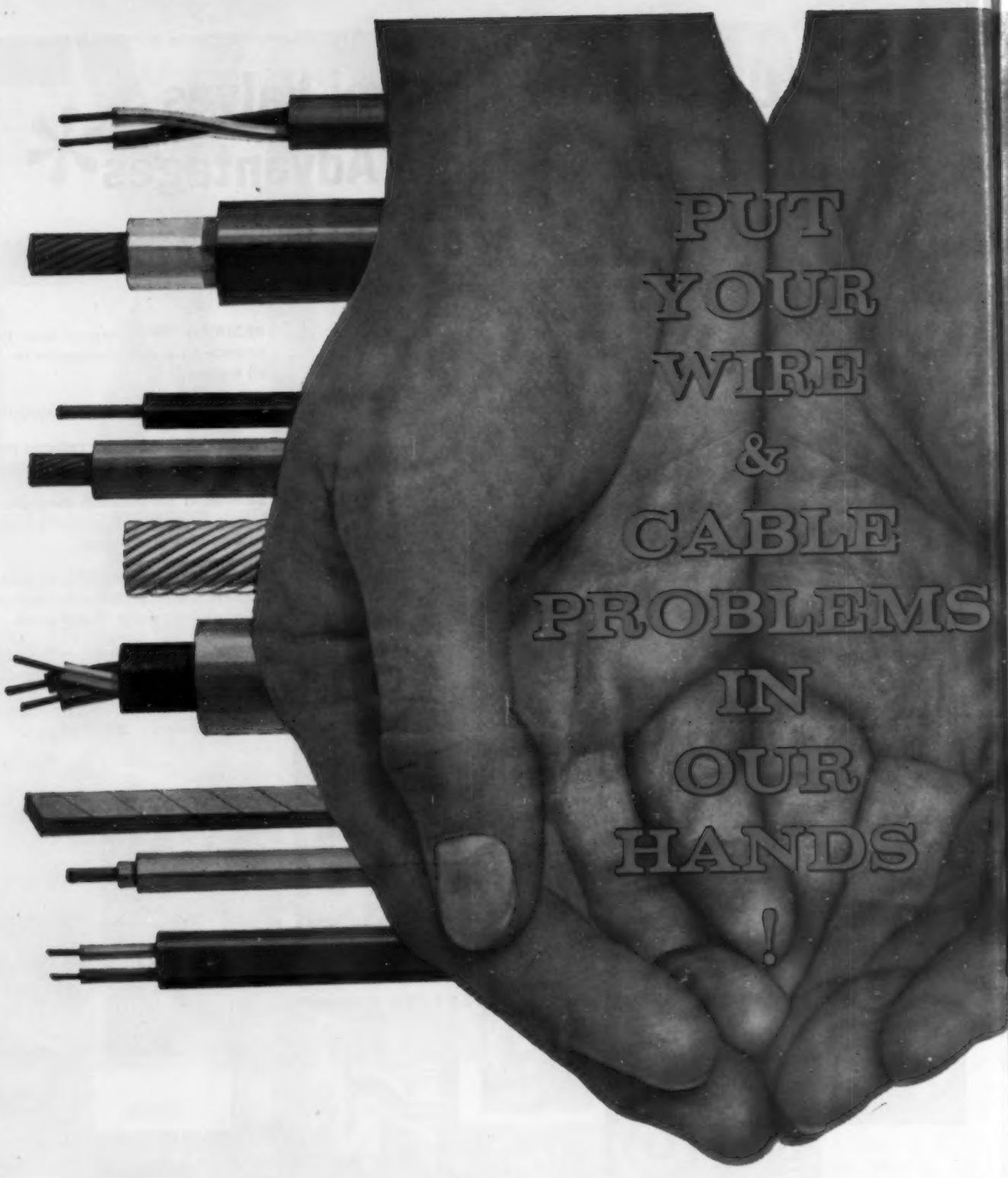

To help conquer extremes . . . from known to th

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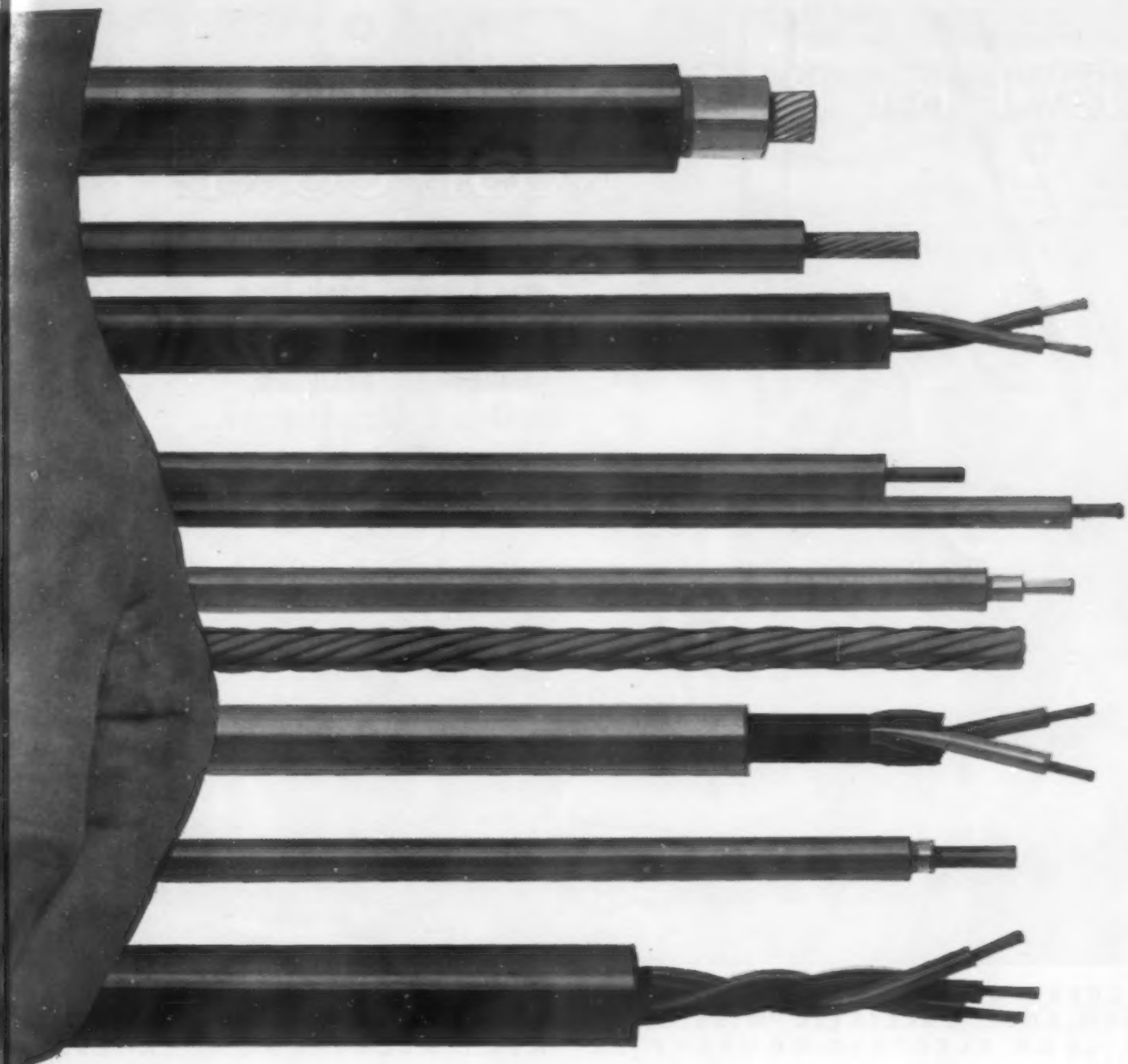

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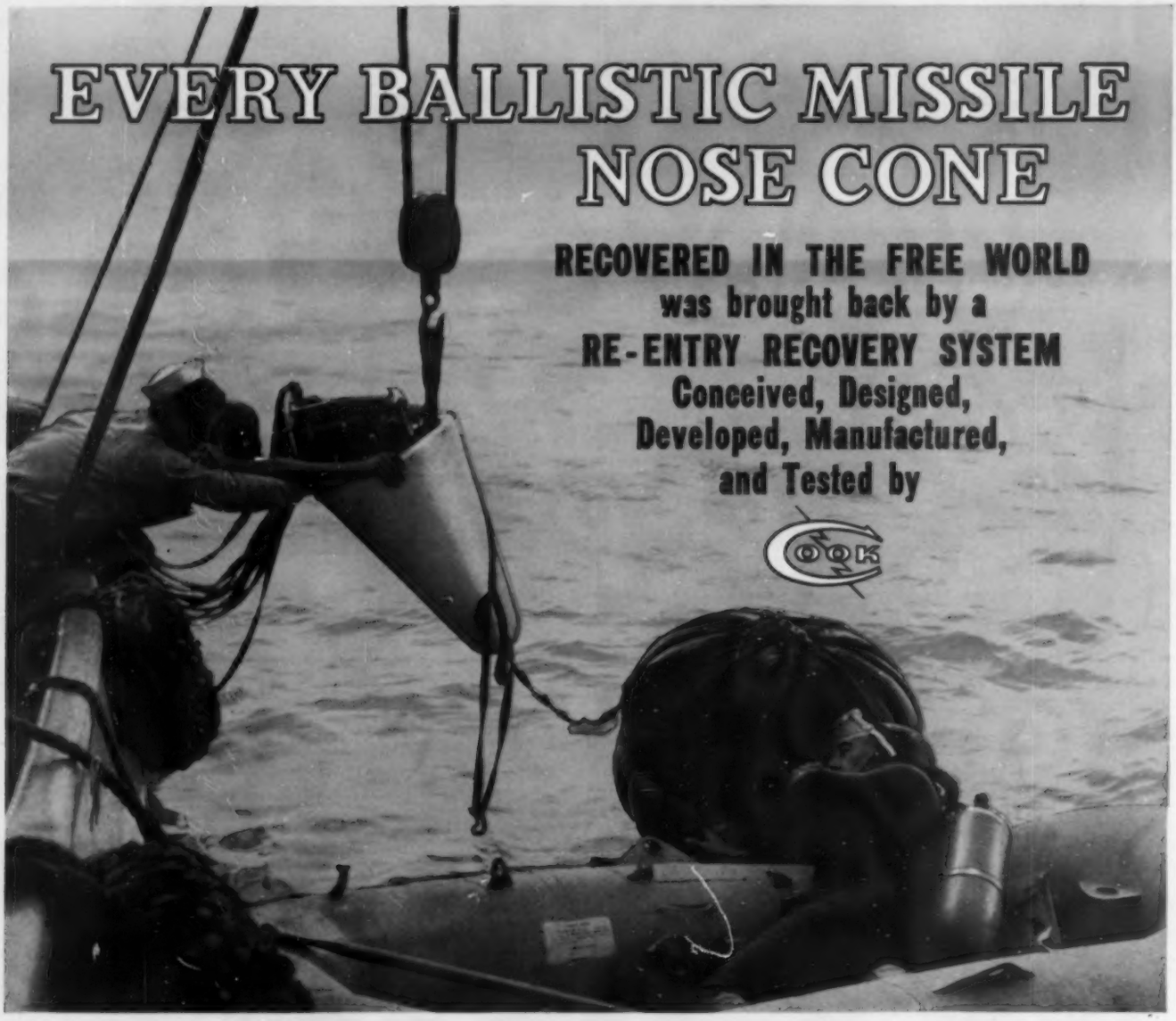

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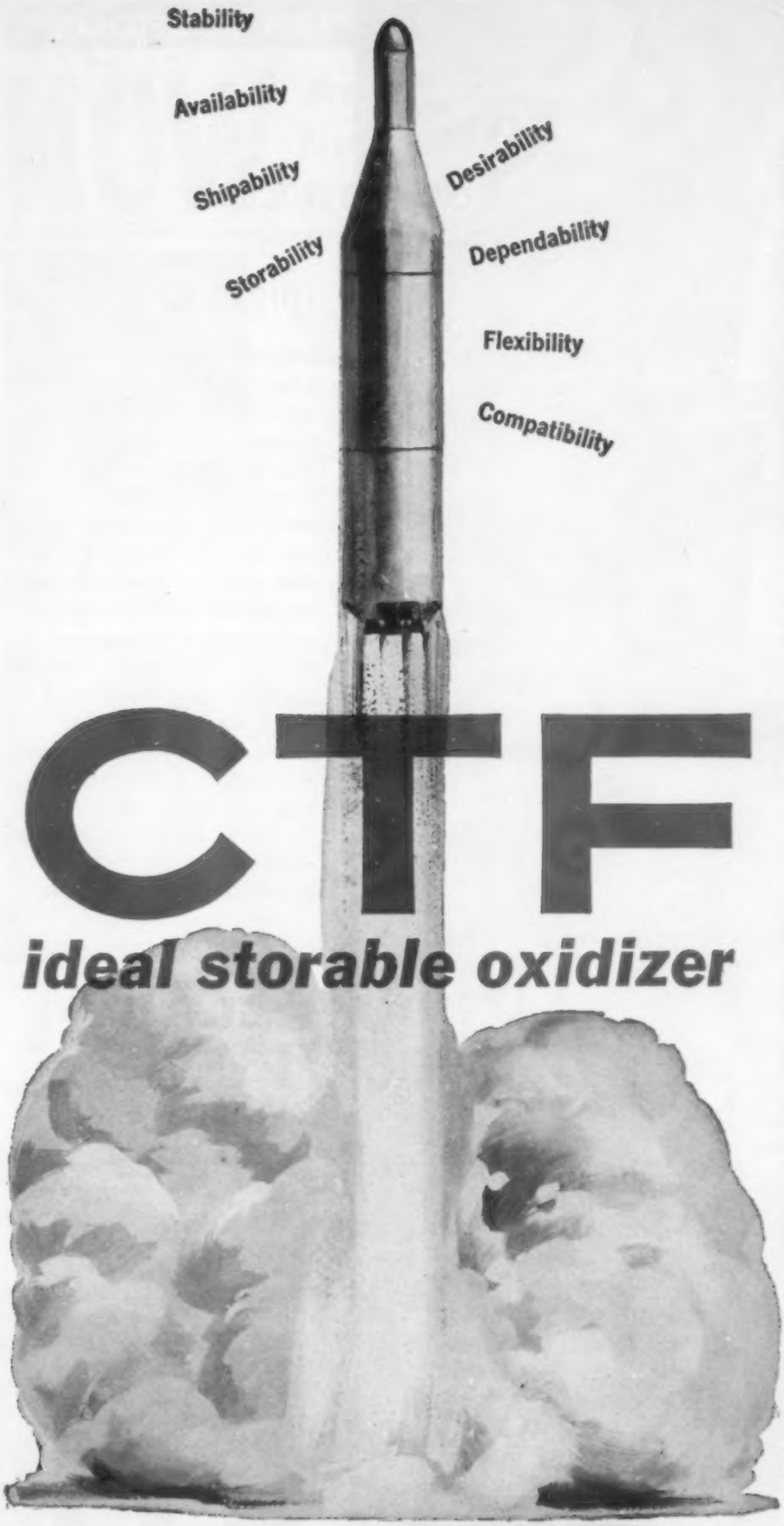

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—Chlorine Trifluoride is one of the most powerful rocket fuel oxidizers known. Its performance compares favorably with other oxidizers far more difficult to handle.

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—CTF has many characteristics desirable in a storable propellant, with a wide liquid temperature range. It has a low freezing point (—105°F) and a moderate boiling point (53°F). Vapor pressure is 80 psia at 140°F.

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—Unlike most liquid propellants, Chlorine Trifluoride requires no refrigeration. It is handled and stored safely and conveniently in standard steel cylinders. No special storing precautions necessary.

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—CTF's high density (1.825 gm/cc at 68°F or approximately 15.3 lbs./gallon) leads to outstanding density impulse values with a variety of rocket fuels.

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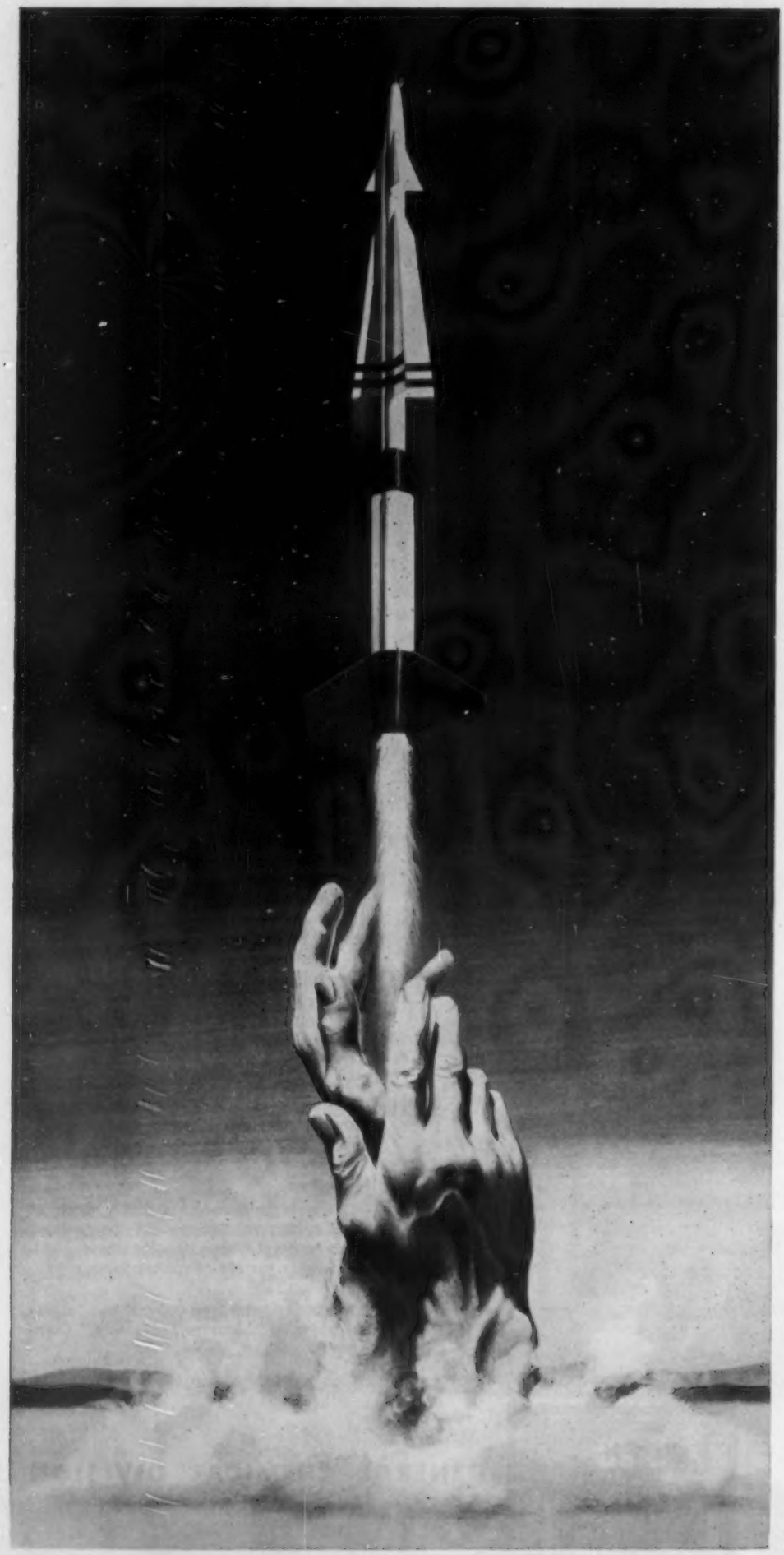

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PROGRESS REPORT

NOW Anocut Electrolytic Machining for CAVITY-SINKING as well as ROTATING-WHEEL applications

MACHINING POCKETS IN FRAGILE STAINLESS STEEL HONEYCOMB FREE OF LAYOVER AND BURR. PHOTO COURTESY EKSTROM, CARLSON & CO.

Rotating-Wheel Anocut

is used for metals which are (1) hard, (2) tough, (3) heat sensitive or (4) easily burred wherever an open surface is to be machined to high accuracy and high finish. It will produce surfaces which are flat or curved (inside or outside) or continuous forms, as in form grinding. Wherever a rotating wheel can be applied this method offers tremendous savings in time and abrasive cost.

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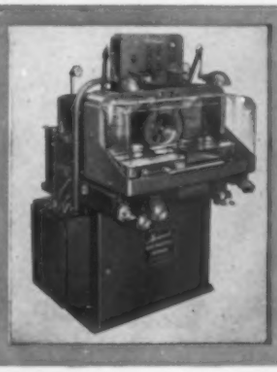

MODEL EG-12 ELECTROLYTIC OSCILLATING GRINDER WITH TWO AIR-OPERATED TILTING TABLES. DESIGNED FOR PRODUCTION WORK ON FLAT SURFACES OF JET ENGINE AND ROCKET ENGINE COMPONENTS AND OTHER TOUGH OR HARDENED STEEL PARTS, DOVE-TAIL OR CIRCULAR FORM TOOLS, ETC. PHOTO COURTESY HAMMOND MACHINERY BUILDERS, INC.

AUTOMATIC ELECTROLYTIC FACE MILL GRINDER. VARIABLE SPEED MOVABLE RAM CAN BE ADJUSTED TO SHARPEN COMPLETE CUTTER IN ONE REVOLUTION OF TABLE, REMOVING .005" TO .020" FROM EACH TOOTH. FORTY-FOUR TOOTH CUTTER, 16" DIAMETER, SHARPENED IN 22 MINUTES, REMOVING .012" FROM EACH TOOTH, GRINDING CARBIDE AND STEEL SIMULTANEOUSLY. PHOTO COURTESY OLIVER INSTRUMENT CO.

NEW MACHINE - SAME PRINCIPLE

Plunge-Electrode Anocut sinks a shaped electrode into hard or tough metals by the same electrochemical principle as rotating-wheel Anocut. Unlike electro-discharge spark machines it has high removal capacity, no electrode wear, and is therefore intended for repetitive production jobs.

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HEXAGONAL HOLE 1" DEEP, ¼" ACROSS FLATS, IN UDIMET 700. NOTE STRAIGHTNESS AND SHARPNESS OF WALLS WHERE ELECTRODE BROKE THROUGH. CONICAL TIP IN BOTTOM OF BLIND HOLE CAN BE ELIMINATED. INTERIOR-COATED ELECTRODE USED FOR ROUND HOLES IN BACKGROUND.

SEVEN INCH LONG, .078" DIAMETER HOLE ELECTROLYTICALLY "DRILLED" IN UDIMET 700. ROD HAS BEEN SURFACE GROUND TO EXAMINE STRAIGHTNESS OF HOLE. NO WEAR ON ELECTRODE.

ELECTROLYTIC TREPANNING. DESIRED FORM EXTENDS INTO INTERIOR OF SHAPED ELECTRODE. NOTE HIGH FINISH ON BLADE FORM.

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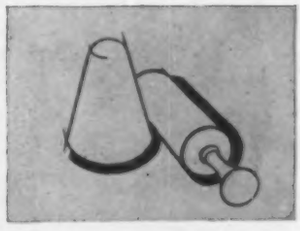
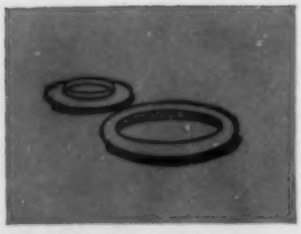
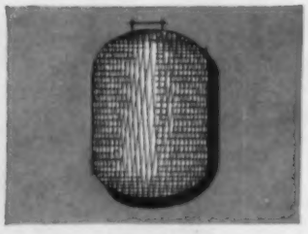
GARLOCK



MISSILE PARTS FROM INERT MATERIALS include newly developed asbestos-phenolic compound for nozzles . . . nose cones of fluorocarbon plastics.



GARLOCK METAL FITTINGS FOR ROCKET MOTOR CASES such as bias: tube and thrust terminator support rings are machined to extremely close tolerances. Made from special materials affording minimum weight, maximum strength and rigidity.



FILAMENT WOUND ROCKET MOTOR CASES made by exclusive Garlock method results in structure much lighter and stronger than steel.

INSULATION FOR SOLID FUEL ROCKET MOTORS made by Garlock is rubber-like compound which encounters gas velocities of Mach 3, temperatures to 5500° F, prolonged ambient temperatures of 300° F.

Garlock components are presently used in the development and production of:

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Nike Hercules • Super Tartar • Terrier • Polaris

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$\dot{v} = \frac{F}{m} - \frac{\rho v^2 d^2 C_D}{2m} - g\phi$
$\dot{\phi} = -\frac{g}{v}(1-\phi^2)\left[1 - \frac{v^2}{gn}\right]$
$G\frac{dT_s}{dt} = h(T_p - T_s)$
$\sigma E T_s^4$
$I = \sqrt{\frac{RT_0}{\gamma g_c}}\left[\frac{F_s}{F_a} + \sqrt{2(\gamma+1)} - \frac{P_2 A_2}{P_1 A_1}\right]$

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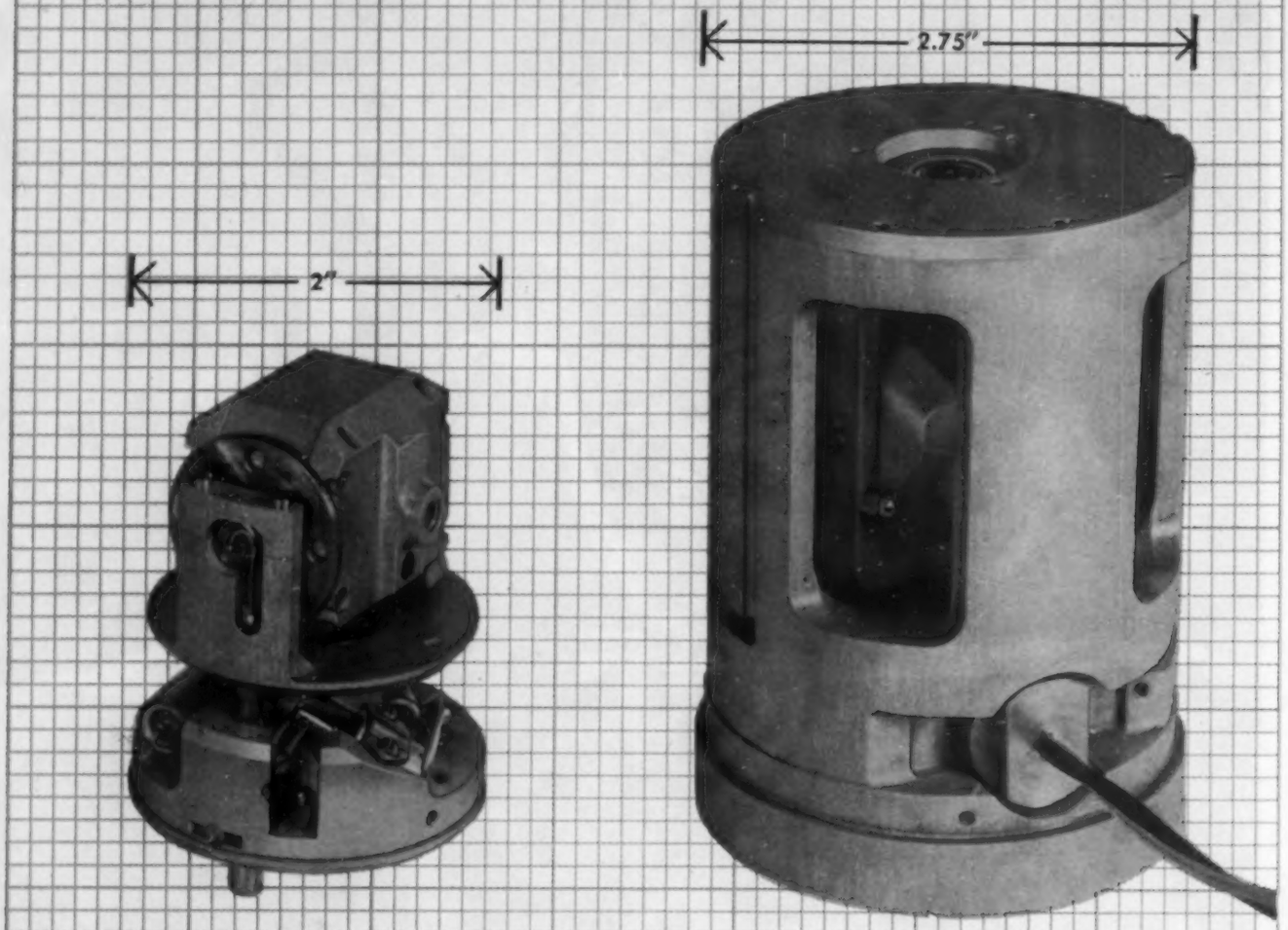

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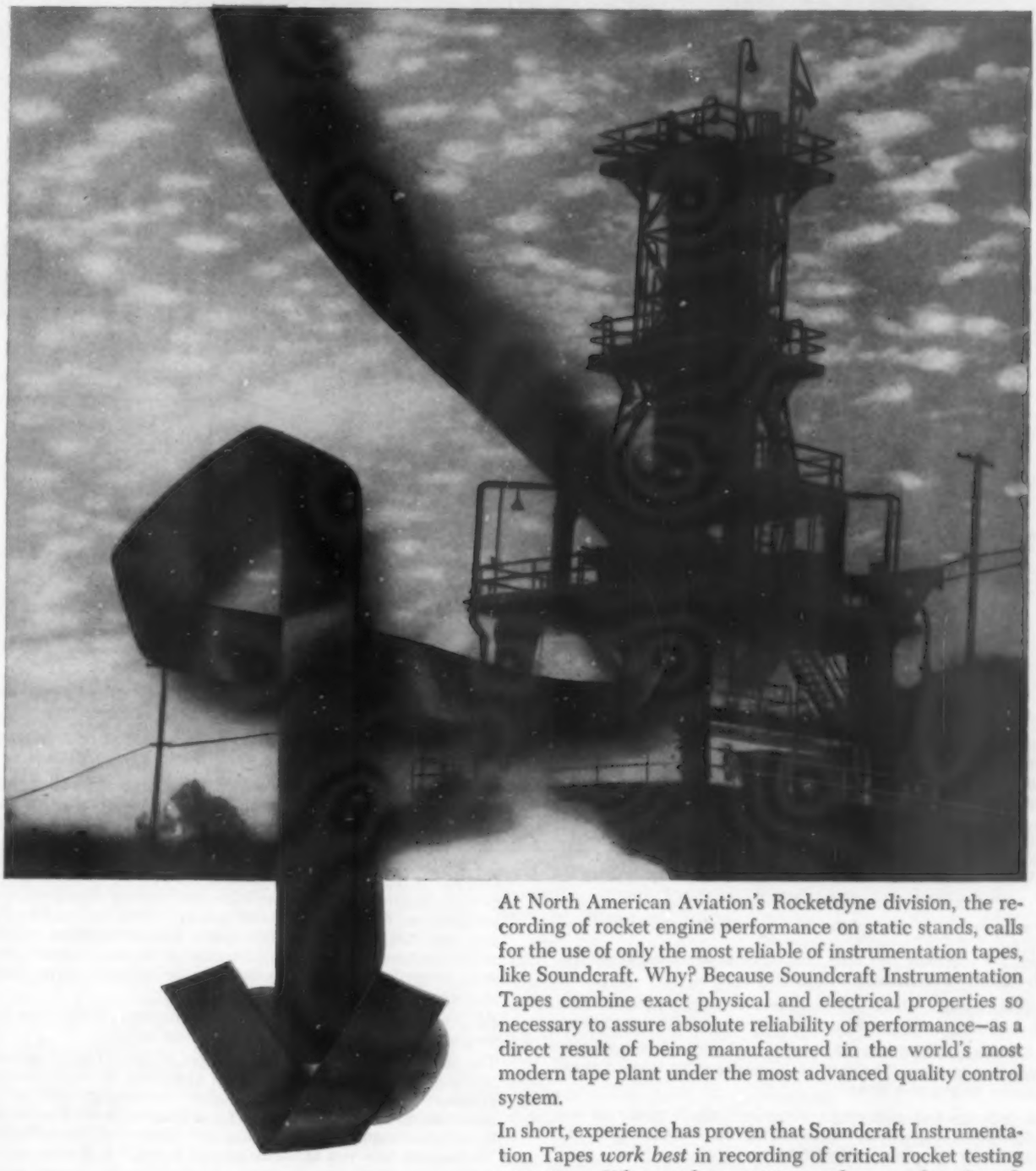

At North American Aviation's Rocketdyne division, the recording of rocket engine performance on static stands, calls for the use of only the most reliable of instrumentation tapes, like Soundcraft. Why? Because Soundcraft Instrumentation Tapes combine exact physical and electrical properties so necessary to assure absolute reliability of performance—as a direct result of being manufactured in the world's most modern tape plant under the most advanced quality control system.

In short, experience has proven that Soundcraft Instrumentation Tapes *work best* in recording of critical rocket testing operations. Why not let precision-made, error-free Soundcraft Instrumentation Tapes go to work for you? Complete literature on request.

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Nerve Centers For A Satellite

Over 25,000 informative cloud-cover pictures have been received from TIROS I since it was launched on April 1. In two months the satellite had completed 1000 orbits and travelled 27,500,000 statute miles. This means not only that TIROS itself has performed as planned, but that the complex problems of command and control, as well as signal reception and processing, have been successfully surmounted. Like the satellite, the special ground station equipments were designed and built by RCA Astro-Electronics Division under the auspices of NASA and technical direction of the U.S. Army Signal Corps.

Major components at each of the four ground stations include:

- Five TV receivers and four beacon receivers used in diversity reception to minimize signal fading
- A programmer which pre-programs different combinations of operating modes, and a 200 watt command transmitter
- A TV monitor to display the picture signal for the automatic recording camera. The camera is equipped to make either positive or negative films
- An indexer and sun angle computer which generate an index number and sun angle indication for each picture, used for geographical orientation
- An attitude recorder which picks up the earth-horizon signal for spin axis position computation
- Two standard 4-channel tape recorders to back up the monitor
- Two paper recorders to monitor forty telemetered satellite parameters
- An antenna programmer which directs the antenna to follow the orbit of the satellite when it is in range of the ground stations

All program functions are timed by a master clock which is synched to standard time signals from WWV. In addition to normal picture direct transmission and record functions, the programmer can also command spin-up. After two months the spin rate had decreased to 9.4 rpm's due to the effect of the earth's magnetic field. On command from the ground, two solid propellent spin-up rockets on the satellite were fired, increasing the spin to 12.8 rpm's.

AED's own ground station was used to process photos from the magnetic tapes for the first one hundred orbits.

The integrated design and development of these TIROS ground stations is an indication of AED's capability in *total satellite systems*. This capability will become increasingly critical as more and more complex satellites and space probes are launched to advance man's understanding and control of his universe. To discover how you can draw on this broad R & D experience, contact the Marketing Manager, RCA Astro-Electronics Division, Princeton, N. J.

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tempting to Kremlin . . .

Will Castro Get Red Missiles?

by James Baar

The ominous possibility that Russia will provide Cuba with missiles is haunting U.S. strategists this week.

Only a month ago such an idea was generally considered far-fetched. Following the events of the last few days, it has to be taken into consideration in all U.S. planning for the Western Hemisphere.

Cuban Boss Fidel Castro and his red henchman, Ernesto Guevara, are swiftly moving Cuba into the Soviet economic orbit as the last fiscal ties with the United States are snapped.

A Soviet decision to "sell" Castro missiles and provide a military mission to help establish Cuban missile bases would be only another step in implementing a Russian move into the Western Hemisphere.

Unless thwarted by stiff—possibly armed—U.S. action, the Cold War gains for Russia would be enormous:

- Castro would have placed in his hands weapons with which he could cause great difficulties for the United States.
- Cuba could intimidate all of Central America and resume the Castro regime's previously ill-fated attempts to spread the Castro Revolution and expand Cuban territorial holdings.
- Russia would have a new bargaining counter with which to demand withdrawal of U.S. overseas bases.
- The Communist Bloc would have a powerful base from which to increase its activities throughout Latin America.

The Russians are known to have large stockpiles of tactical and intermediate-range ballistic missiles from which they could draw for "sales" to Castro. These missiles could be deployed in Cuba at fixed bases or on mobile platforms.

IRBM's launched from Cuba could hit much of the United States. New York, Washington, Chicago and Denver would be within range. Shorter-range tactical Soviet missiles such as the *Komet 2* could hit much of the Deep South—including the *Polaris*-loading depot at Charleston, S.C., and Cape Canaveral.

But even more important to Soviet and Cuban strategy is that such missiles could hit any city or military target throughout Mexico and the small nations of Central America.

CUBAN-BASED IRBM's (made in Russia) could be launched 1500 nautical miles to strike targets throughout Central America and much of the United States.

They could strike anywhere in the islands of the West Indies and across the Caribbean into Venezuela, Ecuador and northern Brazil.

The Panama Canal could be held hostage.

Castro, armed with Soviet missiles and a growing army, would become the greatest military power in Latin America.

Soviet Premier Nikita Khrushchev would face relatively small losses in exchange for such attractive gains.

The principal loss would be the alarming of Latin American nations. This could result in possible united armed action against Cuba and the stiffening of resistance to local Communist groups.

However, Khrushchev apparently does not consider this a serious risk or he would not have openly defied the Monroe Doctrine with his threat earlier this month to come to Cuba's aid with ICBM's.

Nor would a Latin American war embroiling the United States necessarily not be to Khrushchev's taste. He and Latin America's Communists might well feel that whatever Cuba's fate, the odds are in favor of their emerging in control of many key Latin American posts.

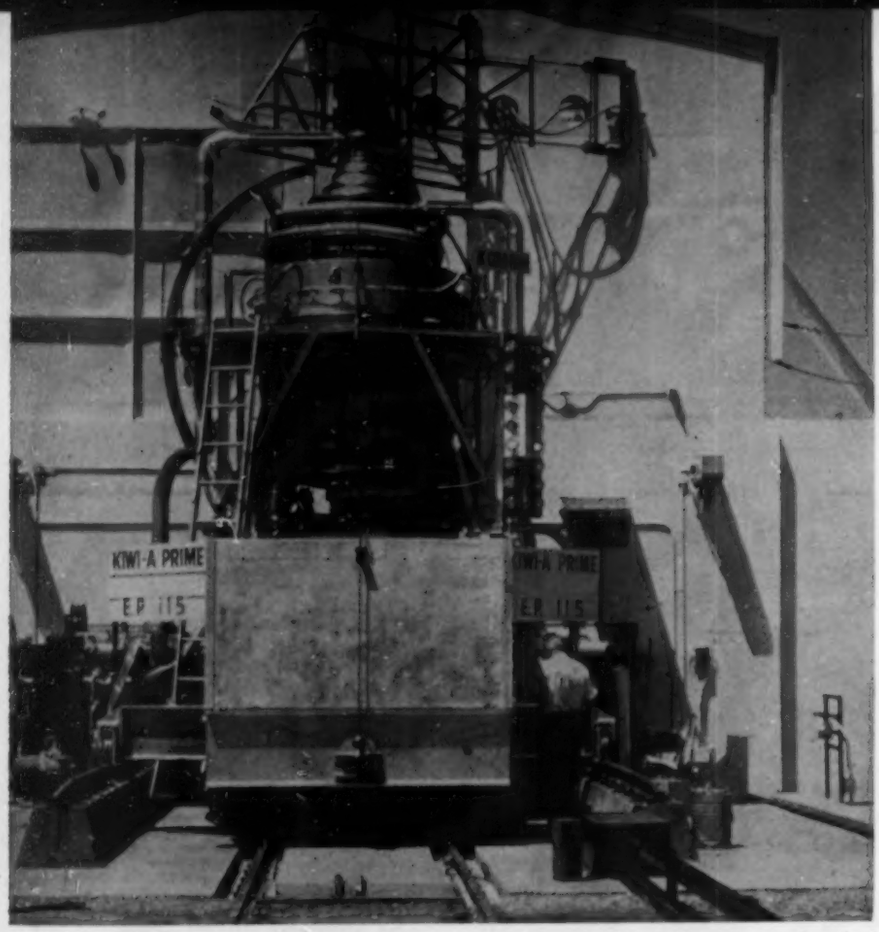
All in all the arming of Castro with missiles must appear very attractive to the Kremlin in the last days of the Eisenhower Administration.

Boeing Gets $247 Million For More Minuteman R&D

The Air Force and Boeing Airplane Co. this last week announced the signing of a $247-million R&D contract for the huge *Minuteman* ICBM program.

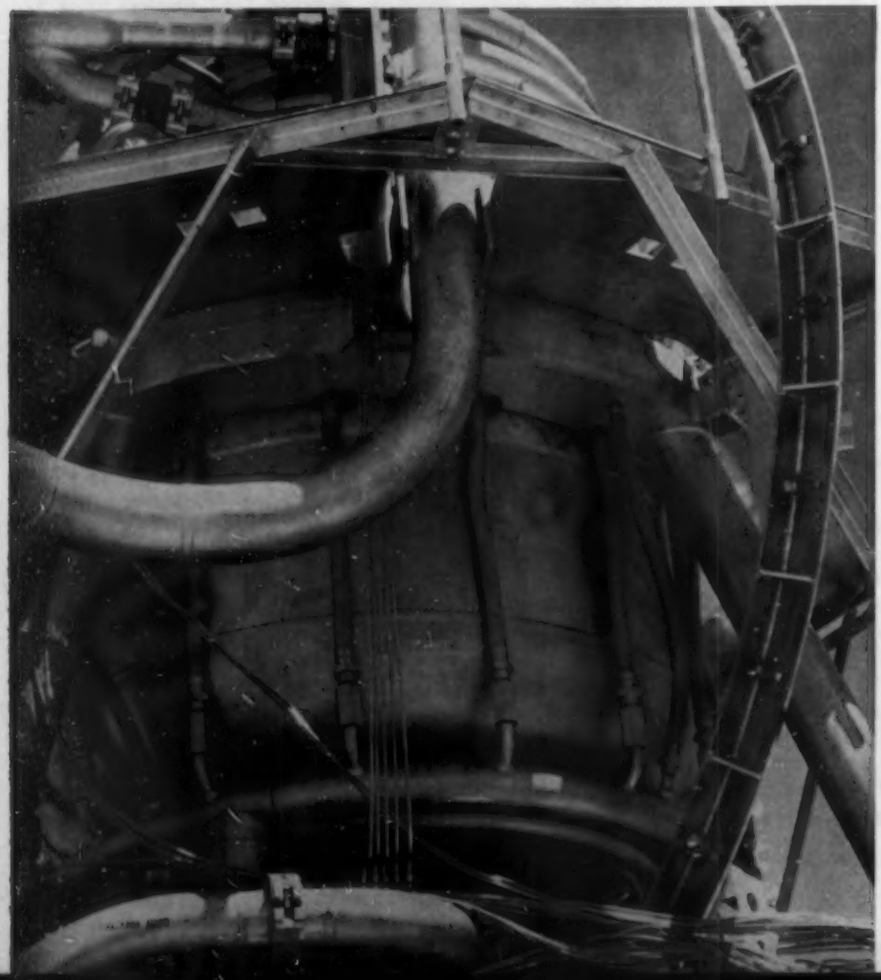
The contract, running through Dec. 31, 1961, replaces a letter contract that authorized Boeing to begin work on the *Minutemen* that will be deployed in fixed bases. A contract covering *Minutemen* that will be deployed aboard trains is expected to be negotiated during the next few months.

The three-stage *Minuteman* is scheduled to be operational in mid-1962.



ABOVE: Kiwi-A-Prime reactor shown on rails in exclusive M/R photo. Its fuel element is believed to represent a major improvement over earlier Kiwi-A.

BELOW: Close-up of Kiwi-A-Prime reactor cold flow unit shows ducting of system used for handling liquids, instrumentation wiring and structural member arrangement.



Theories proven . . .

Kiwi-A-Prime

by Richard van Osten

The U.S. took one more step along the path to a nuclear-powered rocket with the first full power run of Project *Rover's* Kiwi-A Prime reactor at the Atomic Energy Commission's Nevada test site.

Although total power time was approximately 15 minute and full power was maintained for only about five minutes, personnel from Los Alamos Scientific Laboratory expressed extreme pleasure with the July 8 results.

Exact details of the test operation are still pretty much under wraps. But Dr. Keith Boyer, project director for NTS, told M/R the power obtained was "similar" to that achieved with the successful run of Kiwi-A last year.

Output of the solid-fuel (uranium-235) heat-exchanger, direct, open-cycle reactor was not the test's primary object, however. What LASL scientists were trying to achieve was a validation of their design theories. This, they claim, was accomplished.

Kiwi-A Prime is the nearest approach so far to a system and component design that could be flown—not that the reactor is anywhere near a flyable configuration, it is simply "a lot closer," according to test personnel. It is being developed jointly by the AEC and the National Aeronautics and Space Administration.

Security regulations do not permit full disclosure of differences between Kiwi-A and Kiwi-A-Prime. It is known, however, that one major area of improvement is the fuel element—a long-standing problem with all reactor types.

• **Test delayed**—The test went well despite a several hour delay when a methane supply line valve malfunctioned. The methane is used to light off the cloud of hot hydrogen which rises from the reactor nozzle so that it burns rather than accumulate undetected and possibly explode. Operations could have been conducted with-

Run Brings Flight Closer

Testers highly pleased with success of first full-power trial of advanced reaction; Rover director sees program on right track

out the methane flare, but B-57 sampling aircraft took a rather dim view of flying through an unburned cloud of hydrogen. The reactor had to be shut down for the repair, then brought up to power again.

During the full power run, sparks shot out of the reactor exhaust on several occasions. Dr. Alvin Graves, director of LASL's Test Division, said he had no idea what the reason was, but teardown, scheduled to begin the following day, would probably show some slight internal damage.

Another short delay was encountered early in the test when the reactor's scram system (for fast shutdown) was set too close to the operating point.

Next step will be detailed examination of Kiwi-A-Prime following disassembly. Later this year, Kiwi A3, presently still at LASL, will be brought to the site for tests.

• **Kiwi B series**—Kiwi A3 is "almost identical" to Kiwi-A-Prime, LASL says, but the test program is different. The reactor will be run up to power several times, then run to failure.

When Kiwi A3 experiments are completed, the existing test cell (A) at NTS will be modified for additional hydrogen storage in preparation for next year's test program on the Kiwi B series.

In addition to the modified test cell A, a new unit, test cell C, will be constructed for Kiwi B experiments. Some of this construction is complete —extension of the railroad to carry the reactors, a vehicle road and a water line have been installed. First phase of the test cell proper will be built by Okland Construction Co., Salt Lake City, Utah, under a $1.1 million contract.

Work will consist of a heavy reinforced concrete test cell building, a similarly constructed propellant fill station building, furnishing and erecting two prefabricated metal buildings, constructing a cooling tower and an outdoor power substation, installing utility systems, and installing government-furnished equipment. The new test cell is expected to be operational by the summer of 1961.

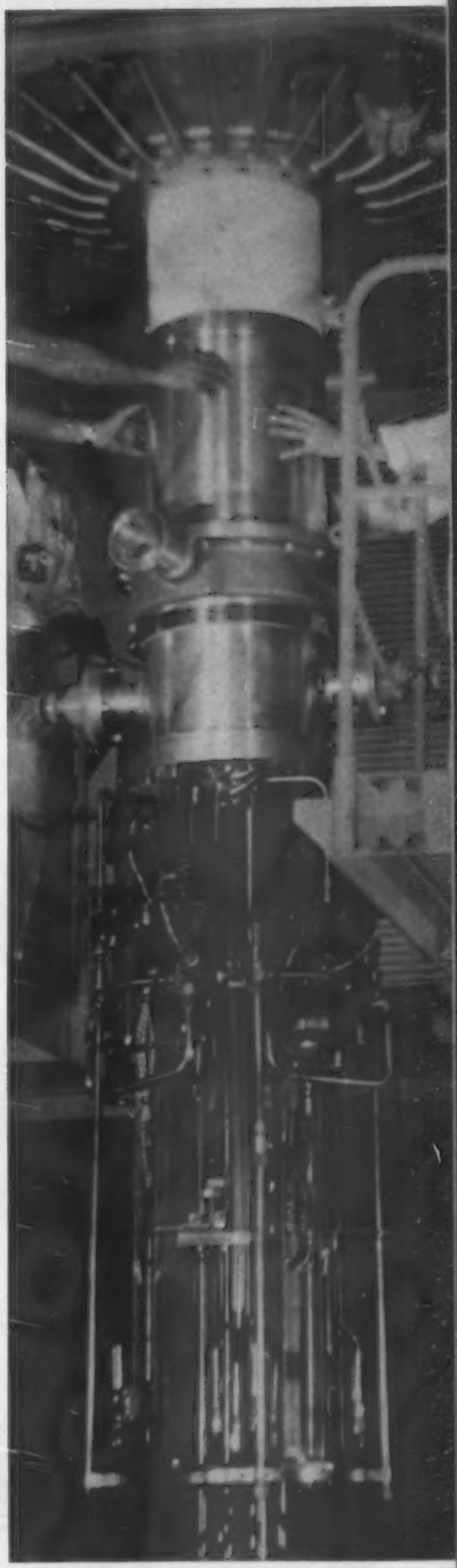
The power run of Kiwi-A-Prime marked still another innovation. This was the first time LASL personnel had tried out a new instrumentation system, which incorporated multiplexed and commutated data pick-off signals which are fed to Ampex recorders. The tapes will subsequently be fed into an IBM 704 computer for reduction.

• **Look for surprises**—The previous system (M/R, July 4, 1960) worked well, but much information was not reduced because of the complexities. With the new system, Dr. Boyer said it is easier to reduce all data rather than select portions to be reduced as before.

Asked his opinion as to the feasibility of the *Rover* project, Dr. Boyer said he was personally convinced they were on the right track—particularly after the successful test of Kiwi-A and now, Kiwi-A-Prime.

"But," he cautioned, "we still have not mastered the problem, and we may be due for some surprises."

The Kiwi-A-Prime test was observed by U.S. Senators Albert Gore (D-Tenn.), Henry Jackson (D-Wash.), and Wallace Bennett (R-Utah), all members of the Joint Committee on Atomic Energy. Other congressional observers were Representatives Craig Hosmer (R-Calif.) and William Bates (R-Mass.). Observers included also representatives from the AEC, NASA, National Academy of Sciences, the Military Liaison Committee, Joint Committee of Atomic Energy, and Dr. York's office.



INTERNAL assembly is installed in hot reactor at Nevada Test Site. ACF assembled hardware. Photos by Frank McGuire.

many applications likely . . .

'Laser' Broadens the Radio Spectrum

by Hal Gettings

A new era in electronics opened up this week with the long-sought development of the laser—an optical maser and key to optical-frequency communications.

The "laser"—Light Amplification by Stimulated Emission of Radiation—extends the radio spectrum from 50 gigacycles (kmc) up to 500,000 gigacycles, which includes infrared and approaches visible light.

An extension of such magnitude vastly increases the number of available communications channels.

This first laser was developed at Hughes Aircraft Company's research laboratories in a company-funded project under the direction of Dr. Theodore H. Maiman, a senior staff physicist.

In addition to radar and communications, a host of other applications are seen for the new device.

The laser is the first true light amplifier. It provides a new scientific tool for investigating properties of matter and performing basic experiments of physics. It can be used as a source of highly concentrated light for industrial, chemical, and medical purposes.

• **Coherence**—The most significant factor of the new development is that the laser is able to generate a "coherent" beam—heretofore possible only in the conventional radio frequencies. "Coherence" signifies the definiteness of the frequency of radiation—the smaller the band, the more coherent the source. Usual light sources—such as a carbon arc or incandescent lamp—generate energy over a relatively wide band of the electro-magnetic spectrum. Consequently, they cannot be focused to a very narrow beam, and dissipate rapidly with distance.

As an example, the best available searchlight aimed at the moon would spread over 25,000 miles—even if it could reach that far.

In contrast, the laser radiates an almost perfectly parallel beam, less than one-hundredth of a degree of arc wide. Aimed at the moon, such a beam would illuminate an area less than ten miles wide. A beam directed at the earth from a satellite at 1000 miles altitude would be concentrated into an area about 200 feet wide. Using it as a "light-radar" could make it possible to take detailed pictures with a super-clarity never before obtained.

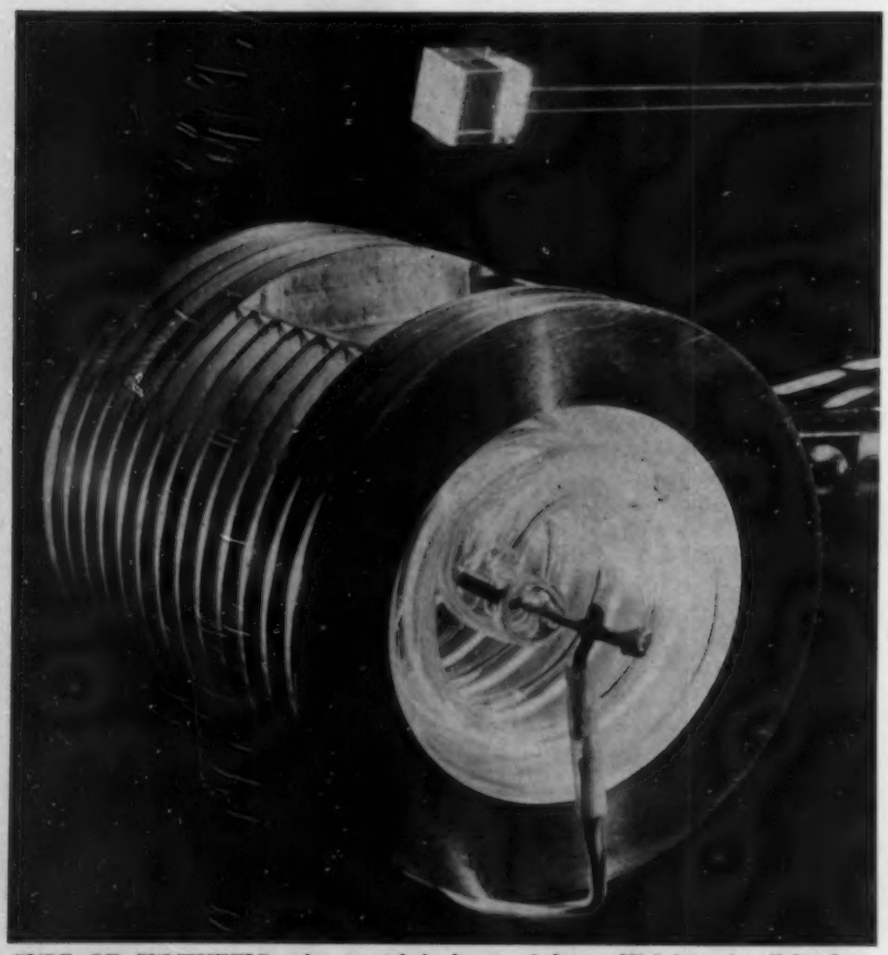
The heart of the laser is a half-inch cube of synthetic ruby crystal. Irradiated by a light source—such as a powerful flash tube lamp—the tightly packed atoms of the ruby are excited to a higher energy state and energy is reradiated in a narrow band of frequencies. The excited atoms are coupled to an atomic resonator and stimulated to emit the radiation together. This is in contrast to ordinary light sources where the atoms radiate individually at random and produce "incoherent" light energy.

• **Glorious color**—Due to its coherence, the laser is a source of very high "effective" temperature, while it itself remains physically cool. By comparison, an ordinary arc lamp would have to be at an impossible temperature of several billion degrees to generate as bright a signal as the laser.

Coherence, too, has an important effect on color. Since the color of light is a manifestation of its frequency band, its purity is determined by the width of the emitted spectrum. Consequently, the laser should be able to generate the purest colors ever known.

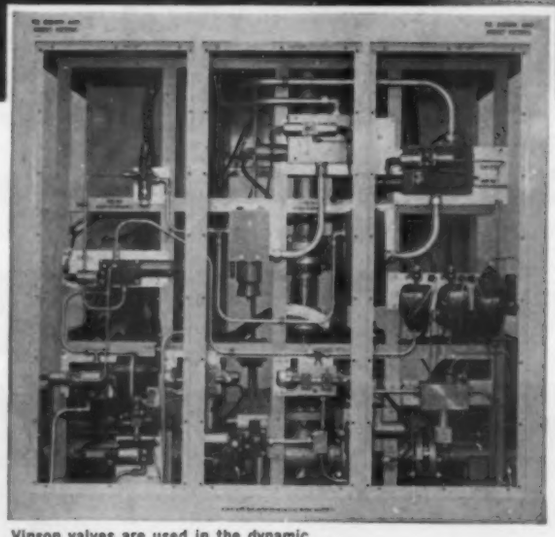
The Hughes effort in this field is one of several programs being conducted in many industrial and educations scientific laboratories. Some are privately and some publicly supported; others are under defense contracts.

Competition in even such an exotic area as this is not unknown. It is fairly certain that parallel or similar significant advances will make their appearance in the near future. The Hughes development is but the first.



CUBE OF SYNTHETIC ruby crystal is heart of laser. High-intensity light from flash tube lamp (glass helix in center) excites ruby's atoms which reradiate sharp beam of coherent light.

WILL IT WORK UP HERE?



Vinson valves are used in the dynamic checkout unit built by Consolidated Systems Corporation for use in the Atlas missile program.

Behavior of helium and nitrogen valves can be predicted if you simulate conditions and pre-test on the ground. Pressure regulators, relief valves, and flow controls must be better than the systems they are checking. It takes knowledge gleaned from experience to design ground support units that guarantee expected behavior of a missile *up here.*

Vinson designed valves and regulators for both the dynamic and static checkout systems for the Atlas. Whether your control problem is simple or complex, consult Vinson engineers.

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Flow and pressure *regulators.*
Reservoirs and *accumulators.*

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Navy Buys High-Accuracy Norwegian ASW Missiles

The Navy is planning to equip two destroyer escorts with Norwegian ASW *Terne* missiles.

The *Terne* is a surface-to-underwater missile that carries a depth-charge warhead. It is manufactured by Kongsberg Vapenfabrikk.

The Navy announced this last week the award of an approximately $1.5 million contract to Arma for the integration of *Ternes* into present shipboard missile systems—presumably *Alfa*—and the modification of existing fire control equipment.

The newest model of the *Terne*—the Mark 7—weighs 264 lbs. The depth charge alone weighs 105 lbs. The *Terne* is 77.5 in. long. It has a 7.9-in. diameter.

Alfa, which has been operational aboard U.S. ships since 1952, weighs 500 lbs. It is 102 in. long and has a 12.7-in. diameter.

Alfa's effective range is about 900 yards. *Terne's* range is believed to be longer. *Terne's* accuracy has been described as "better than a quarter of 1%."

Terne is launched from Norwegian ships with a 2.5-ton deck launcher that carries six missiles, fired singly or in salvoes.

Exclusive M/R photo of *Terne*.

Von Braun Completes Top Staff Appointments

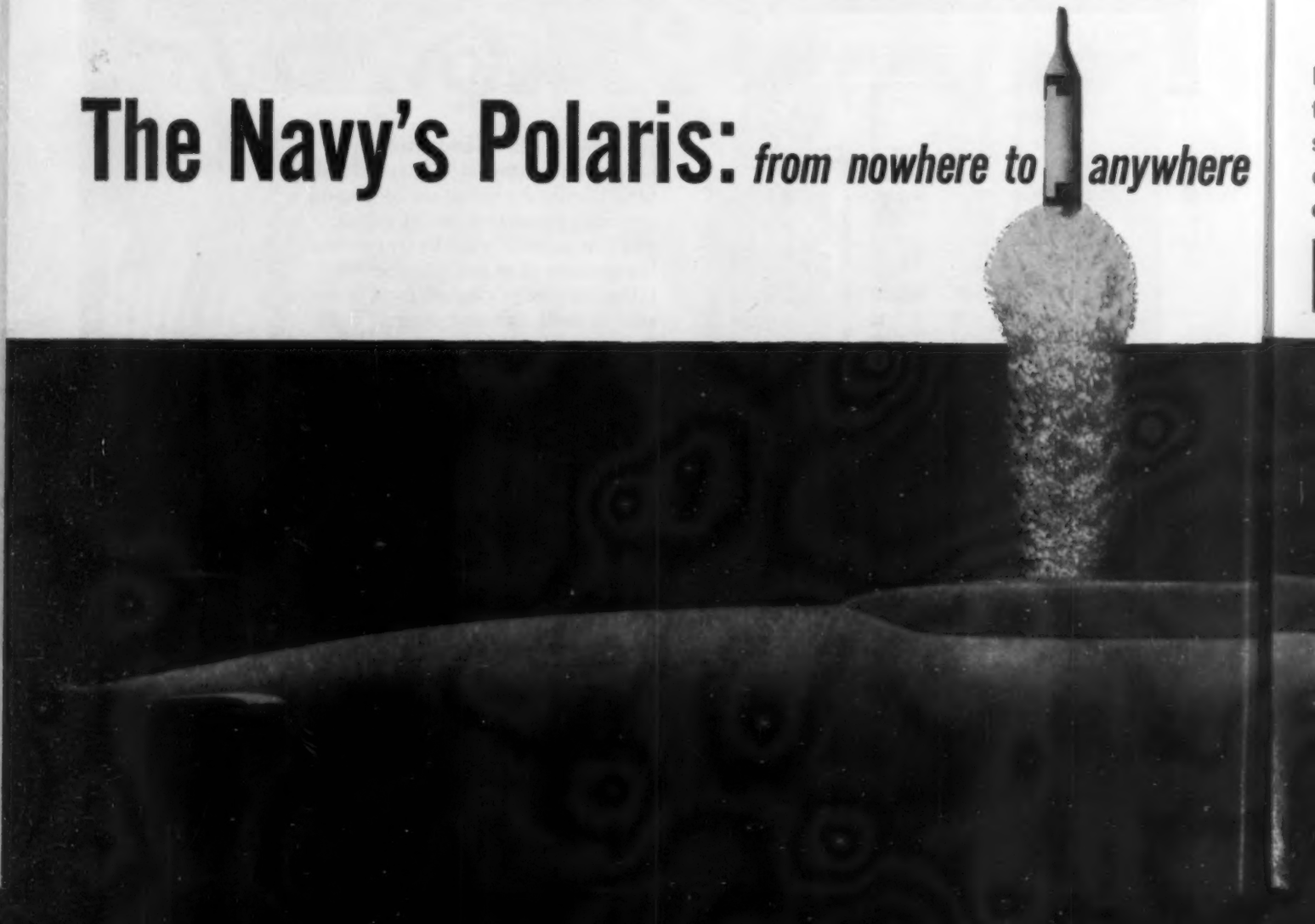
Dr. Wernher von Braun, director of the Marshall Space Flight Center at Huntsville, Ala., last week completed selection of his top staff assistants.

The Marshall Center, which was set up July 1 from von Braun's group in the Army Ballistic Missile Agency, now has a staff of 4900 and eventually will total 5500.

Von Braun made these appointments: Saturn Systems Office, Dr. O. H. Lange; Agena-B and Centaur Systems Office, Dr. Hans Heuter; Weapons Systems Office, Werhen Tiller; Future Projects Office, H. H. Koelle; Technical Program Coordination Office, Dr. George Constan; Office of Technical Services, David Newby; Office of Management Services, V. C. Sorensen; Office of Financial Management, Claude Stockton; Office of Purchasing and Contracting, Wilbur Davis; Management Analysis Office, C. W. Huth.

There are two deputy directors. Dr. Eberhard F. M. Rees, von Braun's deputy for many years with ABMA, will head the operating departments as deputy director for research and development. Delmar M. Morris, government administrator formerly with the Atomic Energy Commission and TVA, is deputy director for administration.

The Navy's Polaris: *from nowhere to anywhere*



NASA Seeks New Western Source of Liquid Hydrogen

The National Aeronautics and Space Administration needs a second supply of liquid hydrogen in the California-Nevada area, it told industry last week.

At a preliminary bidders' conference July 12, representatives of about 15 companies were told that in about a year there will be requirements for additional supply varying from 35,000 to 60,000 lbs. daily for a period of five years. The only major source on the West Coast at present is a Linde Co. plant at Torrance, Calif., which went on stream June 27.

Under a NASA-Linde contract, NASA has first call on up to 275,000 lbs. a month produced at the new Linde plant. Linde has said the plant can produce six tons a day if required.

The NASA group, headed by William P. Kelly, Jr., head of the Procurement Assistance Branch in the Procurement and Supply Division, told the industry representatives that requests for bids would be issued in the near future.

The NASA spokesmen said it was believed that the plant could be built in a year. Several industry spokesmen disagreed, saying the construction would take more time.

It was indicated that the contract to be awarded would provide that the winning company build the plant with its own funds and NASA would be committed to buy from the second plant after first meeting its needs from the Linde plant.

The present NASA contract with Linde calls for the purchase of liquid hydrogen on the following basis: First 100,000 lbs. in any month at 66¢/lb., next 50,000 lbs. at 57¢/lb., next 50,000 lbs. at 55¢/lb., and last 75,000 lbs. at 32¢/lb.

Firms Compete for Contract On Orbiting Observatory

Four companies and seven teams of companies are bidding for a contract to design and develop a 3500-lb. orbiting astronomical observatory (OAO) for the National Aeronautics and Space Administration.

The observatory, largest payload attempted by NASA to date, would carry telescopes and other instruments and point them at parts of the sky with the accuracy and steadiness of a ground telescope.

The OAO would be boosted into orbit by an *Atlas-Agena B* vehicle. Harry J. Goett, director of NASA's Goddard Space Flight Center, told the House Appropriations Subcommittee in March that OAO would go into operation in about 2½ years. This would indicate a flight by late 1962.

The Goddard Center, which will move later this year from Washington to Greenbelt, Md., will have charge of developing the satellite. NASA did not say how much money would be involved in the contract. However, it was understood it would be worth upwards of $10 million to the winner.

Astronomical observation from above the atmosphere is greatly improved because it avoids the distortion of visible light and the blockage of radiation in many wavelengths caused by the atmosphere. Rudimentary observations by rocket have already changed many of the ideas previously held about the nature of the galaxy.

NASA asked for bids on May 5. Bids were received July 5. Individual companies bidding were Lockheed Missiles and Space Division, Aeronutronics Division of Ford Motor Co., Hughes Aircraft and the General Electric Missiles and Space Division. These were the team bids:

Bendix and Republic Aviation Systems Division, The Martin Co. and General Precision Instruments Inc., Westinghouse Electric and Grumman Aircraft, McDonnell Aircraft and Philco, Aerojet-General and Motorola, the three-way combination of Radio Corp.

Erupting from the ocean that blankets most of the earth, the Navy's Polaris missile will have the range to reach any strategic target. It will be launched from mobile bases that are safe from surprise attack—nuclear-powered submarines that cruise fast and deep for weeks on end, each carrying 16 Polaris missiles. This is the Navy's Fleet Ballistic Missile system. It becomes operational this year. Lockheed is prime contractor and system manager for the Polaris missile.

LOCKHEED MISSILES & SPACE DIVISION

3 VITAL SPACE AGE ANSWERS ...THROUGH ULTRASONICS

1. HOW MUCH?

Acoustica Ultrasonic Sensors provide near-instantaneous, completely safe response to liquid-level changes as small as 1/32" with complete reliability... in practically any liquid... with extreme reliability... infinitesimal power drain... at temperatures from −423°F to +500°F.

2. HOW FAST?

Acoustica Propellant Utilization Systems... proven both in ICBM flight and in the ground-support environment... report and automatically control the *rate* of propellant loading and the rate and ratio at which liquids are fed to missile engines in flight. They help insure successful adherence to flight plans.

3. HOW CLEAN?

Acoustica Ultrasonic Cleaning Systems assure the absolute cleanliness needed by electronic and mechanical components for in-flight and in-space reliability. With Acoustica's special *Multipower* techniques, parts are literally *blasted* free of even invisible dirt particles for maximum protection against malfunction.

How Acoustica is equipped and staffed and what it produces to help solve some of the Space Age's basic problems is described in our latest brochures. Write today for our "PORTRAIT OF CAPABILITIES"

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ACOUSTICA ASSOCIATES, INC.
10400 Aviation Blvd., Los Angeles 45, Calif.

of America, North American Aviation and Perkin-Elmer Corp., and the four-way combination of Douglas Aircraft, Itek Corp., International Business Machines and Vidya of the Massachusetts Institute of Technology.

Soviets Finish Latest Series of Pacific Shots

Russia completed testing a new long-range rocket by firing it 8070 miles into the Pacific testing range and impacting the dummy last stage "right at the target point."

The July 7 firing was the second and last in a phase of testing which began only two days before. Tass said the first rocket travelled 8078 miles, although the Pentagon estimated the distance as 7700 miles. U.S. Navy planes reported sighting both flights although they could not determine whether the payloads impacted in the target area.

The Soviets expressed complete satisfaction at the results of the two tests. Tass reported that "these launchings yielded all data necessary to complete the development of a carrier rocket designed for further conquest of outer space."

STL Among Four Companies Doing Moon Payload Study

Space Technology Laboratories last week won its first contract with the National Aeronautics and Space Administration.

NASA chose STL and three other companies to make five-month competing studies of design and size of a package weighing about 2500 lbs. that would make a soft landing on the moon. The others are McDonnell Aircraft, North American's Missile Division and Hughes Aircraft.

STL has been free to contract for competitive government business since July 1, when Aerospace Corp., a non-profit organization, was formed to provide the Air Force with systems engineering and technical direction of missile systems, and took over such work from STL.

NASA announced on July 10 that its Jet Propulsion Laboratory will negotiate contracts with the four companies calling for studies to be completed in December. The individual contracts will be in the neighborhood of $100,000. However, the winner of the competition will be in line for NASA business totaling $50-$100 million over the next several years.

STL has designed payloads for NASA in the past. But the work was done in its capacity as an agency of the Air Force. A division of Thompson-

(Continued on page 62)

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MORE PERFORMANCE PER POUND!
AIRBORNE MILITARY RADAR
Advanced terrain clearance, terrain weather surveillance, and fire control systems.
ANTI-SUBMARINE WARFARE
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Geneva-loc actuators, timing and sequencing devices, and high-response clutch actuators.
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INSTRUMENTATION
Airborne and ground telemetering systems and components and digital data handling and control for industrial and military applications.
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Pioneer and one of major sources for active, semi-active and passive homing guidance systems.
SYSTEMS RESEARCH
Advanced development, systems analysis and operations research.
TEST EQUIPMENT
Design, development and production of tactical and manufacturing support equipment for weapons systems.
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MEET SOME OF THE AIRCRAFT/MISSILE/SPACE SPECIALISTS BACKING UP THE WESTINGHOUSE SALES ENGINEER:

A. M. Bruning, Engineer-In-Charge, Advanced Development Group
Age: 33
B.E., Johns Hopkins, 1949
M.S., Mathematics, University of Pittsburgh, 1956
Specialties: Arc Heated Aerodynamic and Thermodynamic Test Facilities, MHD Research Facilities
Years with Westinghouse: 8

W. J. Walker, Engineer-In-Charge, Aviation Facilities Group
Age: 42
B.S.M.E., University of Southern California, 1949
Specialties: Wind Tunnels, Sonic Fatigue Test Facilities, Hardened Base Equipment, Launchers
Years with Westinghouse: 11

R. A. Feranchak
Age: 29
B.S.E.E., Youngstown College, 1952
Specialties: Arc Heated Aerodynamic and Thermodynamic Test Facilities, Explosive Forming, Rotating Equipment Test Stands
Years with Westinghouse: 7

R. F. Leepa
Age: 29
B.S.E.E., Lafayette College, 1953
Specialties: Military Power Plants, Radar Antenna Drives
Years with Westinghouse: 6

P. J. Hawkshaw
Age: 36
B.S.E.E., Catholic University, 1950
Specialties: Continuous-Flow and Hot Shot Wind Tunnels, Explosive Forming
Years with Westinghouse: 9

J. McDonald
Age: 43
A.B., Chemistry, Engineering, Physics, University of California, 1938
Specialties: Arc Chamber and MHD Generator Development
Years with Westinghouse: 13

H. C. Lee
Age: 40
B.S.E.E., Chiao Tung University (Shanghai), 1942
M.S., Engineering, Cornell University, 1949
Ph.D., Cornell University, 1951
Specialties: Arc Chamber and MHD Generator Development
Years with Westinghouse: 2

H. A. Zollinger
Age: 30
B.S.E.E., Michigan College of Mining and Technology, 1951
M.S.E.E., University of Pittsburgh, 1958
Specialties: Drive Systems for Loaders, Elevators, Erectors and Launchers
Years with Westinghouse: 9

Westinghouse

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VIBRATION

. . . to stop it, find it!

That's the first step. Then you've got to monitor or measure it before you can move in for fast control.

Consolidated takes you all the way in finding and measuring vibration . . . with an airborne system for turbojet and turboprop engines . . . and meters and filters for analysis of turbine engines in test cells and on run-up stands . . . with ground equipment that detects and measures vibration in such static industrial devices as pipelines and air-conditioning systems.

Engineer checks out airborne vibration amplifier at Consolidated Systems Corp.

Where's your vibration problem?

If it's airborne, consider Consolidated Systems Corp.'s vibration-monitoring system. Its transistorized design and printed circuitry assure reliability and compact packaging. The four-channel modular amplifier is easily accessible and the four CEC vibration transducers are operative to 500°F. This system requires only 5 watts.
Write for Bulletin 3011A-X9.

FOR GROUND APPLICATIONS
CEC's portable Type 1-117 Vibration Meter is equally efficient in the field, in the laboratory and on the production line. Provides direct indications of average vibratory velocity and peak-to-peak displacement on a large, easy-to-read meter.
Write for Bulletin CEC 1538C-X1.

Transducer Division CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

A SUBSIDIARY OF Bell & Howell · FINER PRODUCTS THROUGH IMAGINATION

(Continued from page 58)

Ramo-Wooldridge Inc., STL will continue to provide systems engineering of ICBM weapon systems until development is completed. Aerospace Corp. took over the supervision for new missiles and advanced detection systems.

The moon payload, a follow-up to Project *Ranger*, has no name as yet. It will be boosted by an *Atlas-Centaur* vehicle. First flight is expected in 1963. *Ranger* will rough-land a seismometer on the moon's surface about 1962. NASA officials want the soft-land payload to hit at not more than 27 ft./sec., compared with Ranger's speed of more than 300 ft./sec.

A bidders' conference was held at JPL on May 13. Twenty-seven companies filed bids, which were received on June 6.

First Submerged Shot Of Polaris Near at Hand

The *Polaris* test program moved toward a dramatic climax this week as the George Washington prepared to launch the first live *Polaris* while submerged off the coast of Florida.

The test follows nearly 70 launchings of *Polaris* test vehicles beginning in 1957. The program's box score: 46 successes; 19 partial successes; four failures.

The *Polaris*' latest string of launching successes ended July 6 when a malfunction in the 15-ton missile's second stage cut short a flight from a land-based pad at Cape Canaveral.

The next day another *Polaris* veered out of control seconds after it was launched at sea from the Observation Island test ship. A range safety officer destroyed it and the broken missile fell into the Atlantic a few hundred yards from the ship.

GE to Install Trajectory Measuring System at Cape

A $15½-million contract for a new precision missile trajectory measurement system has been awarded to General Electric Co. by the Air Force.

The new system—called MISTRAM—will be first installed at Cape Canaveral. Additional stations will be added later at down-range island sites and elsewhere on the U.S. East Coast. The basic system is scheduled to be in operation by January, 1962.

According to GE, MISTRAM will be more accurate than any trajectory system presently available for U.S. missile test ranges. Basis for the super-accuracy of the system is a method of using phase-stabilization to correct for baseline deviations caused by changes in temperature and equipment. In addition, the system will be able to pin-

←——Circle No. 46 on Subscriber Service Card.

point measuring-station locations on the earth by utilizing orbiting satellites.

A novel feature of MISTRAM is the elimination of precision tracking antennas. Signals received from the missile will be processed by a computer to determine its trajectory from derived position and velocity measurements.

TRW Will Build Solar Power Units for NASA

A $4.3-million contract to supply two Sunflower I solar auxiliary power units in two years was agreed upon last week by the National Aeronautics and Space Administration and TAPCO Group, Thompson Ramo Wooldridge Inc.

NASA announced in April its plan to negotiate with TRW for development of the 3000-watt spacecraft APU, designed to operate for a year within nose fairings usable on *Centaur* and *Saturn* launch vehicles. It will weigh about 700 lbs.

The system will consist of a foldable petal-type solar collector that will open to a diameter of about 32 ft. The sun's rays will boil liquid mercury, which will drive a turbogenerator to produce electric power. An energy storage unit will permit continuous operation, even when the craft is in the earth's shadow.

TRW originally estimated the cost of development at $4.9 million.

Getting Named Head Of Aerospace Corp.

Dr. Ivan A. Getting will be the first president of Aerospace Corp., successor to Space Technology Labs as manager of the Air Force missile and space programs.

Dr. Getting is former vice president for research and engineering for the Raytheon Co., and during World War II was director of fire control and Army radar for the Radiation Laboratory of Massachusetts Institute of Technology. He has also been Professor of Electrical Engineering at MIT.

The appointment is effective August 1.

Broad Range of Topics Scheduled at WESCON

Workshop sessions on the wide-ranging aspects of manned-machine systems will be among the primary attractions in the technical program of this year's Western Electronic Show and Convention (WESCON).

Scheduled for Los Angeles, August 23-26, the West's big four-day electronics meeting is jointly sponsored by Institute of Radio Engineers and

Circle No. 47 on Subscriber Service Card.——→

VIBRATION

... detect it immediately!

First things first. You can't stop vibration until you've isolated it – and CEC produces a transducer family noted for ferreting out even the slightest hint of vibration.

Wherever unbalance is present – in engines, machinery, motors, generators and countless industrial applications – this line of vibration transducers insures fast detection, helps you get right to the heart of the trouble.

CEC'S NEW TYPE 4-123A VIBRATION TRANSDUCER

Now widely used by the aircraft and electronics industries, detects vibration instantly in operating jet engines while airborne or during ground tests. This rugged, omnidirectional transducer assures a frequency response of 45 to 2000 cps with constant damping over a temperature range of −65°F. to +500°F. *Write for Bulletin CEC 1628-X1.*

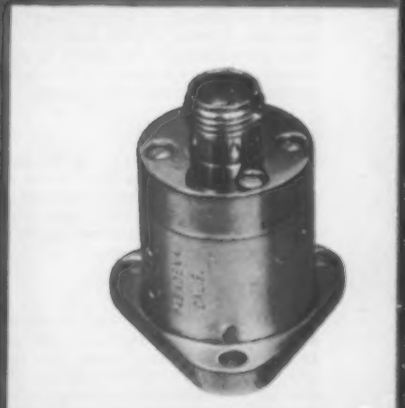
HIGH TEMPERATURE TYPE 4-124

Like Type 4-123A is hermetically sealed against sand and dust, functions perfectly in oily, corrosive and humid atmospheres. When the environment is rugged, Type 4-124 operates at temperature extremes to +800°F. *Write for Bulletin CEC 4124-X1.*

BOTH UNITS SHOWN ACTUAL SIZE

CEC TYPE 4-118

Is ideal for use where space is limited or when a heavier transducer would invalidate test results. Low sensitivity to transverse accelerations and accurate performance in any mounting plane make the 4-118 desirable for mobile tests. Output may be coupled to a recording oscillograph or the unit may be used with a vibration meter or oscilloscope. *Write for Bulletin CEC 1535D-X1.*



Transducer Division CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

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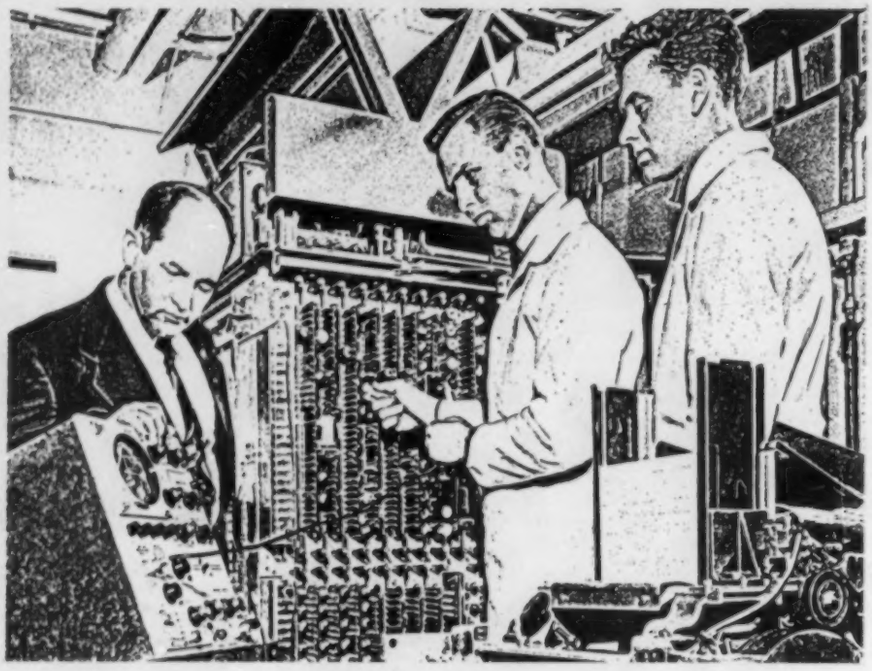
AT UNIVAC...



An Atmosphere of Achievement

There's a fresh enthusiasm at Remington Rand Univac. The opportunity for personal progress and satisfaction has never been greater. We refer to it as Univac's *Atmosphere of Achievement*—an excellent environment in which engineers and scientists can enjoy unlimited opportunities for professional advancement.

Contributing greatly to this atmosphere are demanding programs involving extraordinary degrees of ultra-reliability. One Univac computer, as example, has logged thousands of hours while maintaining a reliability rating of 99.992 per cent.

Opportunities for participation in creative programs of far-reaching magnitude now exist at Remington Rand Univac. Included among those immediately available are:

DEVELOPMENT ENGINEERS

To develop advanced techniques in high speed memory circuits, switching circuits, and other phases of data processing. Engineers are also required for work on communications systems, antenna couplers, and servo-mechanisms.

SYSTEMS ENGINEERS

Engineering, Mathematics, or Physics degree with experience in weapons and missile guidance systems involving digital control, digital conversion, radar and communications information processing, and input-output equipment.

PHYSICISTS

B.S., M.S., and Ph.D. levels for research and development of systems, high speed circuitry of digital computers, and for physical research including evaporative thin film research and ferro-magnetic domain behavior as applied to computer elements.

RELIABILITY & QUALITY ASSURANCE ENGRS.

To perform reliability analysis and predictions, develop failure reporting procedures, analyze failures, recommend corrective action, set up and implement quality assurance programs.

PRODUCTION ENGINEERS

To plan automated processes, methods and tooling for the world's most reliable computers. These openings on production programs require imagination and creativity. Engineering degree preferred, with experience on electronic equipment.

MECHANICAL ENGINEERS

To design and develop miniature airborne electronic packaging which will meet severe environmental specifications.

OTHER OPENINGS

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DIVISION OF SPERRY RAND CORPORATION
2750 West Seventh Street, St. Paul 16, Minnesota

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Western Electronic Manufacturers Association.

Each day's technical program will include a workshop session. Subjects to be included: Management of Manned Machine Systems (moderator: R. L. Clark, DOD); Analysis of Manned Machine Systems (moderator: Lt. Col. A. Debbons, RADD); Synthesis and Design of Manned Machine Systems (moderator: D. T. McRuer, Systems Technology, Inc.); Operation and Training of Manned Machine Systems (moderator: J. Lyman, UCLA).

The program includes 40 technical sessions on electronics and related areas with more than 200 speakers presenting papers. The preliminary schedule lists sessions on the following subjects:

Systems and maintainability; pulse-handling techniques; communications; management of manned machine systems; semiconductor devices and tubes; communication values of the technical symposium; varactors and tunnel diode applications; instrumentation; circuit theory; semiconductor devices;

Computers; stereo multiplex broadcasting; microwave theory and techniques; analysis of manned machine systems; microwave tubes; computer circuits and devices; magnetic data recording; working with engineers; vehicular communications; component and systems reliability; air traffic control;

Antennas; synthesis and design of manned machine systems; microminiaturization; government and industry engineering proposals; the *Pioneer V* experiments; bioinstrumentation systems; military electronics; information theory and modulation methods; operation and training of manned machine systems; coding methods and telemetry.

An innovation in this year's technical sessions will be a women's program on the subject, "Engineering: The Woman's Role."

Cole Connector Uses New Alignment Principle

LOS ANGELES—A new principle for self-aligning contacts is used in a connector developed by Cole Electric Co. for ground service equipment of the *Atlas* weapon system.

Cole has just received a production contract for the connector from Convair Astronautics.

Basic principle of the self-aligning electrical connector is that of a universal joint employing a two-ball split-sleeve design. The ball end of each contact pin mates with a split-sleeve socket that is loosely retained with another ball to form a receptacle unit.

Garter springs on the split-sleeve provide expansion or contraction of

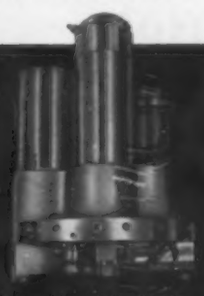
PUMPS – positive displacement types – wide range for handling most types of fluids, speeds to 60,000 RPM

HYDRAULIC MOTORS – compact – gear type / range to 30 HP / speeds to 60,000 RPM – rotation either direction.

VALVES – many types for many uses – hydraulic / pneumatic / manually, solenoid or pressure operated / pressures to 12,000 PSI.

PUMPS – positive displacement types – electric motor driven / operate on wide range of fluids / pressures to 4000 PSI.

PUMPS – dynamic types – submerged and line mounted – electric motor driven fluid pumps with highest V/L ratio – operate on wide range of liquids.



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ENGINEERS

SITE ACTIVATION

We're rolling up our sleeves for the next important step of activating bases throughout the United States. Design or liaison engineers with B.S. in M.E. or E.E. and experience in electrical or mechanical systems are required for liaison work at missile launching complexes, or design support work on launch control equipment, propulsion systems, automatic programming and missile checkout equipment operations.

Assignments are at Warren Air Force Base, Cheyenne, Wyoming; Offutt Air Force Base, Omaha, Nebraska; Fairchild Air Force Base, Spokane, Washington; and in San Diego.

Please send complete resume to Mr. R. Merwin, Engineering Personnel Administrator, Dept. 130-90, 5521 Kearny Villa Road, San Diego, Calif.

CONVAIR/ASTRONAUTICS
CONVAIR DIVISION OF
GENERAL DYNAMICS

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the sleeve to allow easy entrance or withdrawal regardless of the alignment of the pin or connector. Optimum electrical contact is assured.

Cole says the unique two-ball and socket action permits unusual flexibility, allowing the junction to be made quickly and easily even though pins may have become misaligned due to rough treatment, high shock, vibration or extreme temperature changes.

The self-aligning feature also allows angular insertion or extraction without damaging the pins or increasing pressures.

Pressures required to open or close are extremely low. Cole says a 48-contact Cole Connector using #16 pins require an insertion force of 18 lbs. and an extraction force of 15 lbs. compared to 100 lbs. and 125 lbs. for conventional connectors of the same type.

This made it possible to design the *Atlas* system without the use of complex opening and closing devices. Since the self-aligning contact pins can be inserted at an angle without damage, the Cole connector opens and closes like a book.

Use of this hinged action makes possible a lower weight and cheaper unit than the use of screw-on, screw-jack or power-lever types, the company says, and connection and disconnection also is faster and easier.

The unit has been built for rough use. In tests, the connector was dropped more than 5 ft. to pavement some 2000 times without major damage.

Cole reports that the self-aligning principle makes it possible to design a connector with virtually any number of contacts of various capacities. Contact pins for the connectors are available in 15, 30, 75, 150 and 300 amp. capacities and any combination of pins sizes can be used in a single connector.

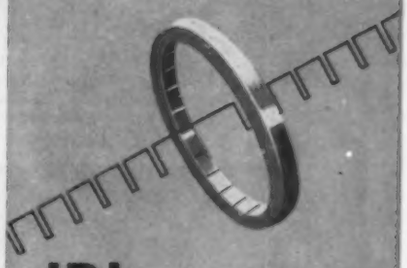
This was done in the connectors for the *Atlas* system, which originally called for a number of different connector designs to accommodate the many cable configurations.

Cole simplified the problem by designing just one basic connector to serve all types of cables.

Pentagon Studying Whether Ads Are Allowable Costs

The Department of Defense is currently conducting a detailed analysis of all trade publications to determine whether or not advertising in them is an allowable item of cost under the Armed Services Procurement Act, according to a letter written by Gen. Arno Leuhman, chief of Air Force information, to the publisher of Air Force Magazine.

Time-Sharing Problem?



IDL MAY HAVE A SOLUTION –

Your data handling system, whether RF carrier or wire transmission line, may require time-sharing to increase its capacity and efficiency.

In the past, the advantages of motor driven switches used for multiplexing were outweighed by their disadvantages. They were smaller, lighter and simpler but, because of high contact resistance, bounce and short life, they contaminated data.

Then IDL introduced multi-fingered brushes traveling on the inner periphery of cylindrical sections to minimize resistance and bounce and extend trouble-free life to hundreds of hours. These concepts have been successfully applied to missiles in sampling 900 data points per second for more than 500 hours without signal contamination even in the milli-volt signal level ranges.

For example, Switch No. 500660 is a complete unit within a compact case, available at reasonable cost and capable of sampling up to 180 transducers. It combines 2 poles of 30 data channels with 2 poles of 60 data channels, each operating at 5 rps.

For further information, write for Technical Bulletin No. 500660; or let us propose a solution to your Time-Sharing Problem.

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28 MECHANIC STREET, ATTLEBORO, MASS.

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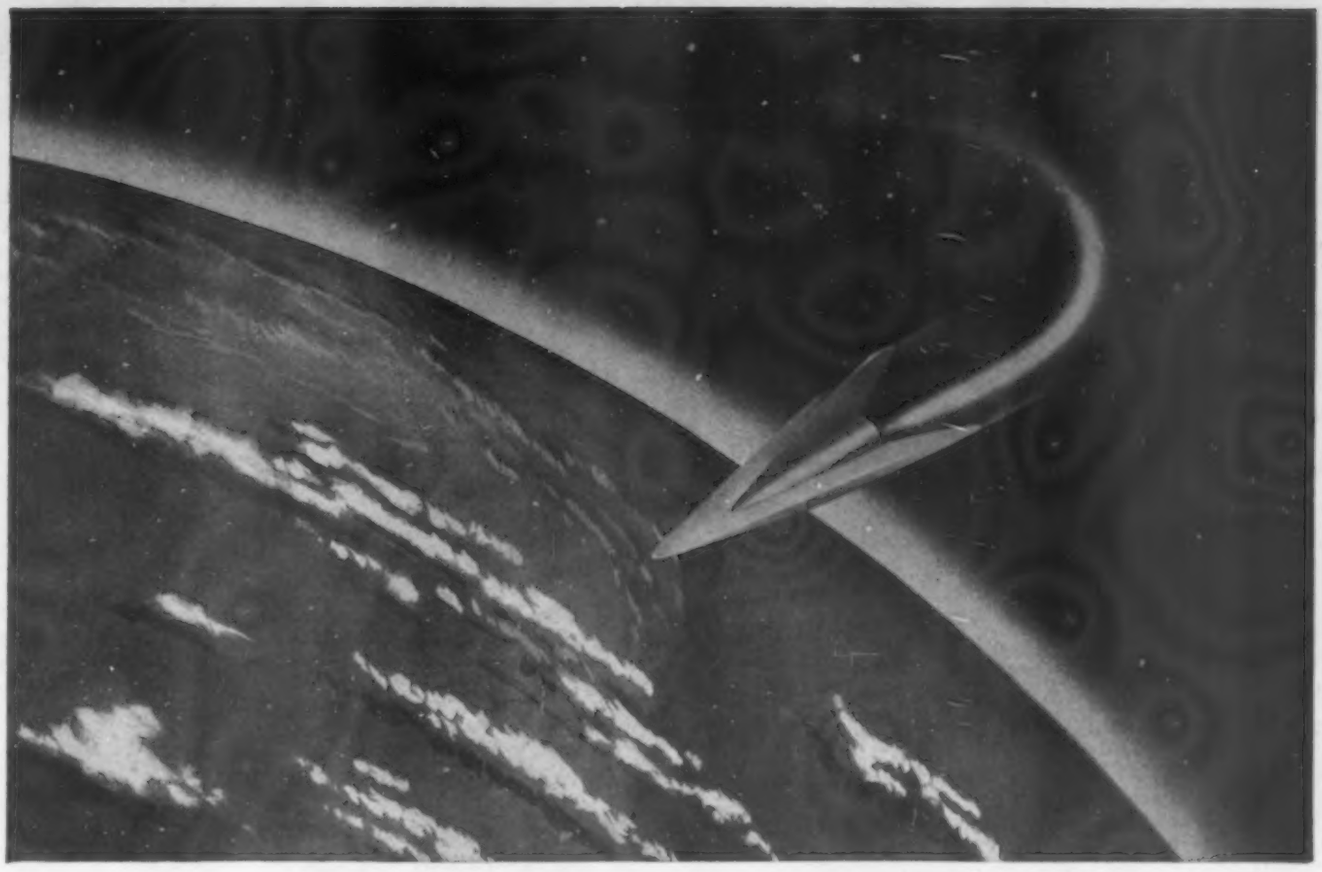

Return from Space

The first astronauts will return from outer space in ballistic capsules with parachute recovery. The re-entry vehicles used by subsequent space travellers, however, will return to earth in controlled glides much as conventional aircraft do.

This problem of "controlled return" is undergoing intensive study at Grumman, with preliminary designs of re-entry vehicles well under way. Collateral projects include space defense weapons, orbiting astronautical observatories, manned lunar vehicles, and upper stages of booster vehicles.

For these and future studies, Grumman is building a team of space engineers and scientists with the following qualifications:

. . . **Navigation and Guidance.** Minimum of 5 years' experience in guidance and navigation and components for missiles and space vehicles.

. . . **Celestial Mechanics and Trajectories.** Minimum of 5 years' experience in celestial mechanics, missile and space vehicle trajectory analysis and related areas.

. . . **Communications.** Minimum of 5 years' experience in theory and design of radar and communication systems with special emphasis on radio guidance, radio and radar tracking and communication systems for missiles and space vehicles.

. . . **Dynamics.** Minimum of 5 years' experience in dynamic analysis, the theory of rigid and elastic body dynamics and/or the design and instrumentation of attitude control systems for missiles and space vehicles.

Send your resume in strict confidence to Mr. A. Wilder, Manager Engineering Employment, Dept. GR-86 to arrange for a mutually convenient interview.

Grumman

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Technical Countdown

ELECTRONICS

New Techniques for Anti-jamming

An interesting concept applied to the problem of anti-jamming protection for communication satellites is termed "graceful degradation." Aim is to have a system capable of stepped-up performance during ECM attack but to automatically lower operating requirements when the satellite is not subject to jamming.

Yes, We Have No Communication Satellites

Most of the work in perfecting a practical communications satellite system is still ahead of us, according to F. R. Kappel, president of AT&T. Contrary to some "over-enthusiastic publicity," he says, a limited system is five years away and commercial applications about 10 years in the future, "if all goes well."

Reliability High for Titan "Athena"

Reliability of the *Titan* guidance computer, Athena, is reported to be rated at 99.92% after over 21,000 hours of continuous operation of four models. Remington Rand Univac has just received AF contracts of over $26 million for production of the solid-state computers.

Ozone vs. Weather and People

An ozone analyzer being developed by Armour Research Foundation at Illinois Tech is expected to shed some light on the part ozone plays in determining atmospheric circulation. Another application is as a monitor for manned space vehicles cabins flying through the ozone layer between 40,000 and 150,000 ft. Even low concentrations of ozone (2 ppm) can cause severe lung irritation.

Down-range Pickle Jar

A "pickle-jar navigation aid" helped a down-range telemetry ship reach its assigned position southeast of Ascension during an *Atlas* shoot some time ago. Devised on the spot by Pan Am technicians, the jar was used as a lighted buoy to determine ocean current drift during a storm that blocked out conventional navigation fixes.

Negative Ions for Health?

A recent Air Force study demonstrates that positive ions, originating mainly from carbon dioxide, promote various harmful effects, including an increased vulnerability to trauma. Negative ions, originating from oxygen, are said to have beneficial effects. Conclusion: fill space cabins with negative ions.

ADVANCED MATERIALS

PH Stainless Process Licensed

Armco Steel granted a license to Republic Steel to produce and sell Armco's 17-7 PH, 17-4 PH, and PH 15-7 MO. Precipitation-hardenable stainless steels are used extensively in supersonic flight environments.

Mach 27 Wind Tunnel in Operation

Boeing has commenced full-scale operation with a "Hotshot" wind tunnel. Hypervelocities are attained by use of electrical energy impulses equivalent to five million horsepower stored in 2280 capacitors. Temperatures up to 14,000°F and simulated altitudes of 50 miles can be reached in the 56-foot tunnel.

ASW ENGINEERING

Batteries vs. Rockets

Solid-fuel rockets for torpedo propulsion will have a hard time pushing batteries out of the picture. Many in the Navy feel that solids have a long way to go technically and that more money in battery research would produce the breakthrough needed to give required high-energy levels.

System is the Thing

ASW weapons should be designed as a system, according to some manufacturers in the business. They say the Navy should decide on a comprehensive and feasible system and go to work on implementing it with appropriate vehicles and hardware.

Drone Helicopter for ASW

A Gyrodyne *DSN-1* drone helicopter made its first at-sea landing aboard the USS Mitscher July 1. The experimental model is the first remote-controlled helicopter built expressly for use in destroyers. It will be used to carry homing torpedoes to kill enemy submarines.

PROPULSION

Agena Engine Passes Restart Tests

The Bell 8081 engine for Lockheed *Agena B* has reportedly passed a series of successful restart tests under simulated vacuum conditions. Tests were conducted at Arnold Engineering Development Center, Tullahoma, Tenn.

Test Sled Hits Mach 3.5

A 2.5-ton monorail sled was boosted to a record velocity of 2650 mph at Holloman AFB last month. The 48-foot sled, largest ever fired at Holloman, covered 5½ miles in 15 seconds. It was propelled by three Hercules Powder Co. *Nike* boosters.

Swan Song for X-7

Final flight is scheduled this week for the Lockheed *X-7*, a ramjet-powered test missile that holds the West's air-breathing-vehicle speed record of Mach 4.31. The program at Holloman AFB will end with this flight, the 130th. *X-7*'s have a success record of 75% in testing ramjet engines and gathering data on exotic fuels over the last 13 years.

Research Needed to Advance Air-breathers

Research in three areas is needed to advance the high-Mach-number air-breathing engine science, speakers told an AGARD meeting in Milan this spring. The areas: high-temperature recombination rates of hydrogen-air and hydrocarbon-air; effect of shock on flow, mixing and combustion; and turbomachinery design.

How Does a Solid Rocket Burn?

Ignition of solid propellants has been shown to occur entirely in the gas phase, contrary to a widely held technical view. So says the Air Force Office of Scientific Research. Bolstering the agency's notion is a partly developed mathematical theory of composite propellant burning based on experimental studies of ammonium perchlorate combustion.

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02

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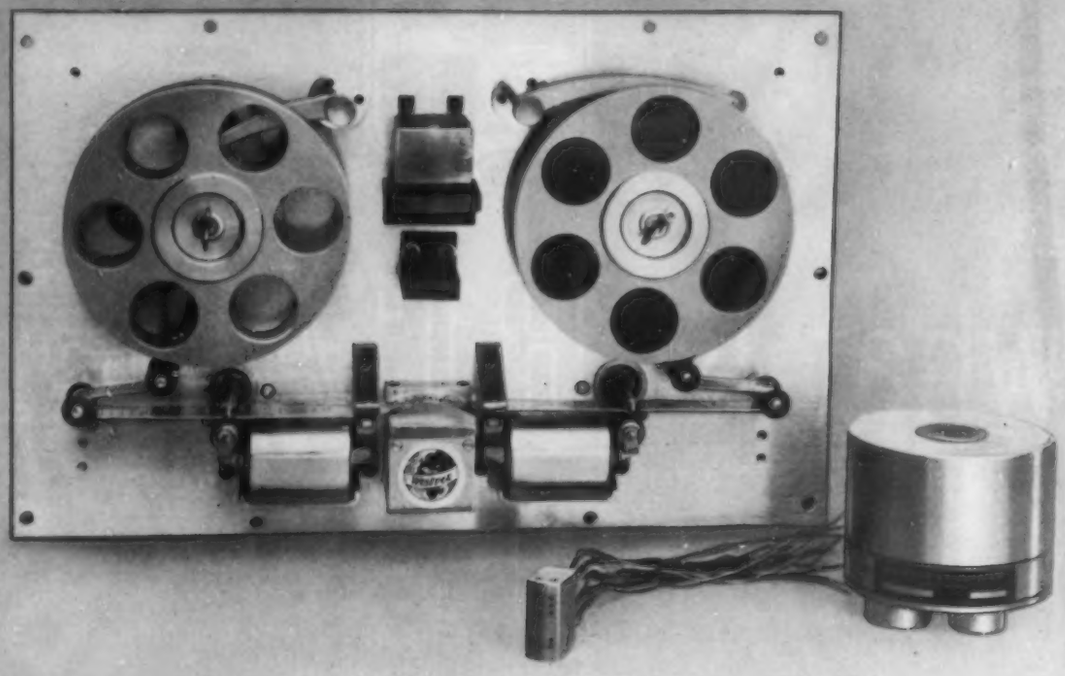

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1960 Propulsion Progress . . .

Hydrogen-LOX Development Exceeds Forecasts

- ***Rapid progress of LOX-liquid hydrogen system is year's most important trend***
- ***Engine hardware is area of greatest solids improvement***
- ***Nuclear rocket gets firm development objective***
- ***Ion engine development programs spur electrical propulsion***

An interview with Elliot Mitchell, assistant director for propulsion, Office of Launch Vehicle Programs, NASA.

The most significant propulsion trend of the last 12 months is the unexpectedly rapid progress of the liquid hydrogen-LOX system.

This is the opinion of Elliot Mitchell, top propulsion specialist of the National Aeronautics and Space Administration. He says that NASA, taking advantage of the trend, has decided to give maximum support to development of a large LOX-hydrogen engine and to exploit the system for upper stages of advanced vehicles such as *Saturn*.

Mitchell, assistant director for propulsion on the staff of Maj. Gen. Don R. Ostrander, NASA director of launch vehicle programs, declared in an interview that Pratt & Whitney Division of United Aircraft has made tremendous progress in its work on a 15,000-lb.-thrust hydrogen engine for the *Centaur* and *Saturn* programs.

"The performance of this engine, including combustion problems, has come along extremely well," Mitchell said. "The handling of hydrogen on a large scale is a lot more reasonable than any of us had optimistically hoped."

The NASA propulsion chief recalled that Rocketdyne Division, North American Aviation, was chosen this spring to develop a LOX-hydrogen engine of 200,000 lbs. thrust, more than 13 times the power of the Pratt & Whitney engine. And the P&W powerplant itself will be uprated to about 17,500 lbs.

Mitchell was asked for his assessment of progress in all major propulsion areas in the last year. He expressed these opinions:

• **Storables**—The combination of nitrogen tetroxide and hydrazine-type fuels has gained momentum, he said. "If we are talking storable liquids, this combination is reasonable and provides a higher impulse."

Mitchell said, however, that not enough is known at present to endorse the use of any storable propellant system for use in space. "We need to understand theoretically and experimentally how high-energy particles affect propellants, the chamber material and their interaction."

Both NASA and the Air Force are making plans for experimental studies simulating radiation and other space environment effects on storable propellants, he added. Industrial contractors have been asked to make proposals.

Mitchell noted also that work is progressing rapidly on the *Saturn* booster and the 1½-million-lb.-thrust F-1 engine. Although no breakthroughs are involved in these LOX-kerosene engines, he said, they are great engineering jobs that are progressing very successfully.

As for *Saturn*, he said the anticipated heat problems have not been severe—"the result of a combination of good fortune and damned good engineering." He added:

"The thoroughness of the Marshall Research Center team's approach under Dr. Wernher von Braun is overwhelming. It is a team effort that is a pleasure to watch."

• **Solids**—The spectacular success of the *Polaris* and *Minuteman* systems in the last year has demonstrated that large solid motors can be reduced to reliable practice, Mitchell asserted.

The area of greatest progress has been in engine hardware rather than in the propellant itself, Mitchell reported. Hardware improvements have taken place in development of high-performance cases, production of reliable, useful thrust vectoring, and termination and solution of insulation problems.

Mitchell said he does not expect any tremendous progress in the near future on improving solids except for some entirely new propellant that might come from the research sponsored by the Defense Department's Advanced Research Projects Agency. And in such a case, he asserted, experience shows that such a new fuel could not be brought into operation in less than five years.

Improvements in the near future, he said, will come from marginal increments of 5 or 6 seconds in specific impulse, better mass ratios and other little tricks.

"But as we go into systems significantly better in I_{sp}, we will find ourselves aggravating many problems that we are handling relatively simply today," he continued. "We may encounter breakthroughs we don't see today, but I feel significant gains in performance will come hard."

Another important development in solids is continuous processing, Mitchell declared. This will be the manufacturing method for any future programs based on large-volume production.

In motor case fabrication, Mitchell predicted a wider application of fiber glass and plastic, which he said has very great growth potential, both in performance and cost.

For large-volume production, steel cases probably will maintain a cost

(Continued on page 84)

1960 Circuitry Progress . . .

Reliability Replaces Size Reduction As Main Objective of Integration

- *Reliability is biggest advantage*
- *Cuts promised in cost, size and power consumption*
- *Integrated circuits demand integrated processes, teams*
- *Need for materials research grows*
- *New assembly and processing techniques required*

by Dr. H. W. Welch, Jr.*

There is much speculation over the impact of recent advances in solid-state integrated circuits on the future of electronics.

Without speculation, it should be possible to review recent activity in this field and provide a measure of progress. This, subtracted from what we know we need to accommodate our present electronics capacity, should give us a less speculative idea of what remains to be accomplished.

To measure progress, we should ask, "Where have we been trying to go?"

The implication of the terms first applied to describe the integrated circuit effort—microelectronics and micromodules—was that reduction in size was the objective.

• **Main objectives**—Recently, however, there has been more emphasis on the reliability—rather than small size—of the equipment manufactured with the new methods. Higher reliability is expected to result from reducing the numbers of interconnections and more closely controlling assembly procedures.

Ultimately, costs should be lowered through reduction in parts inventory, reduction in number of manufacturing processes, and general applicability of mass-production techniques.

Along with size reduction, there may be an increase in speed of action and a decrease in power consumption. These three factors have become important as complexity has increased in terms both of total number of components and of number of different kinds of components. This is particularly true in data- and information-processing systems, which have increased in complexity faster than have signal processing systems.

Increase in reliability and speed, decrease in cost, size and power consumption have emerged as the real objectives we hope to achieve by new approaches to circuit construction. These, plus one other, are no different than the objectives we have had for years.

The other objective—and probably the most important—is to enable systems to perform under environmental conditions never experienced before. As a by-product of the effort we may expect systems to perform new functions in applications not previously conceived or attempted.

• **New approaches, technologies**—These objectives are being approached through greater application of solid-state phenomena and the development of closer integration of circuits.

In the past, circuits have been integrated topologically—through point-to-point interconnection of a variety of components in a readily discernible network. Now we are looking toward three basically different methods of integration in which the network is increasingly less discernable: integration by the overlapping of thin films of solids having a variety of electrical and magnetic properties; volume junctions in semiconducting, dielectric and magnetic solids; and complete molecular integration such as exists in the coupling between electron spins and the lattice in magnetic solids.

To construct integrated circuits by these methods it has been necessary for industry to expand its capability to perform the necessary processes.

Previously, to take an extreme view, the equipment manufacturer had only one process to perform in electrical assembly: soldering. Some had developed capability for printed wiring. Other processes were performed in the mechanical packaging and protection from environment.

With the new approaches to integration, four new technologies become essential for a complete processing capability: semiconductor technology (single-crystal growth, diffusion, alloying, etching, thermo-compression bonding, etching, etc.); thin-film technology (evaporation, sputtering, pyrolysis, masking, surface cleaning and preparation, etc.); electronic ceramic technology (mixing, extruding, pressing, firing, annealing, glazing, grinding, etc.); and solid encapsulation technology (chemical preparation of glasses, deposition of inorganic, non-metallic solids, surface preparation, annealing, etc.).

Along with these process technologies, the measurement of basic electrical properties of solids—conductivity, dielectric constant, magnetic permeability and environmental testing—must be accomplished in order to know that a process has been successful. In addition, means for internal examination of solid-state characteristics such as crystal structure, diffusion depth, impurity concentration, grain structure, etc., must be available.

Most important, does the resulting circuit have the electrical characteristics to perform the functions for which it was designed? In other words, could it be designed in the first place

*Director of Research and Development, Military Electronics Div., Motorola Inc.

and is it reproducible from written process specifications and drawings? This question must be answered by and to the satisfaction of the systems and equipment engineers with their methods of measurement from the terminals of the resulting circuits.

• **Teamwork required**—Integration of processes leads to the need for integration of people into a team. Chemists, physicists, electronic engineers, electromagnetic engineers, mechanical engineers, metallurgists, ceramicists, and techniques highly skilled in vacuum techniques, evaporation, heat treating, chemical processes, and such, must work in close communication as a team to accomplish the end result.

This is borne out by the observation that any completed circuit is so closely tied together mechanically, thermally, and chemically, as well as electronically, that diagnosis of a malfunction might involve any or all of the mentioned disciplines.

The interconnected components approach has led to specialists in resistors, capacitors, transistors, inductances, insulated wire, etc. The integrated-circuit integrated-process approach requires close integration into a team of people with the same special qualifications.

Where We Stand

Now that we have established a yardstick against which progress can be measured, let us see how far we have progressed.

Most significantly, for the first time in the history of electronics, a number of teams of scientists and engineers have been established with the common objective of building electronic systems from the basic solid materials rather than components made by specialists. Ten to 15 such teams exist within the broad spectrum of disciplines mentioned above. The average size is from 20 to 30 qualified scientists and engineers.

My estimate would be that between 300 and 500 scientists and engineers have been assigned to this effort and that less than 15% of these are electronic circuit engineers. This concentration of effort is bringing a refreshing new look into the electronic industry.

• **New discoveries**—Integration of processes has brought many of our solid-state scientists closer to the application with the result, surprising to some, that they are discovering problems of basic nature that they did not know existed. Electrical properties of thin films such as conductivity and dielectric constant are better understood, as are chemical and physical properties such as effects of impurities and vapor pressure.

Chemical interactions between masks, substrates, and circuit elements not isolated physically from one another have been discovered and eliminated by changes in processing techniques. Better control of processes of deposition, diffusion, alloying, crystal growth, surface preparation, etc., has been achieved. New methods for performing these processes have been developed. Crystal growth by the dentritic process, through constraining apertures, and by the epitaxial process is better understood. Each of these methods lends itself to the integrated-process approach to circuit construction.

The suppliers of electronic materials are having demands placed upon them for higher purity and better particle size control. Quantities are still not large enough to make the chemical industries really excited, but they are cooperating.

The semiconductor industry—in addition to looking at new approaches to crystal growth—has developed methods for placing more than one transistor or diode in one semiconducting substrate and have added resistance and capacitance within the same substrate to make complete circuit functions.

• **Adding materials**—Much attention has been given to deposition of tin oxide and high-resistivity metals, and the anodization of tantalum for resistance elements. All of these approaches meet the high designability and reproductibility criteria. Anodization of tantalum and deposition of quartz have met the same criteria for the formation of dielectrics. Conducting and magnetic metallic film deposition has reached a high degree of maturity.

Preparation of ceramic, glass, quartz, beryllia, and alumina substrates is now better understood. Problems of smoothness, cleanliness, and shape control still exist. Substrates other than semiconductor suitable for epitaxial growth of semiconducting solids remain to be found.

Solid encapsulation at low temperatures with glass and inorganic solids of more regular crystalline structure has been achieved but not brought to a high degree of maturity. Organic encapsulants suitable for long-life application have not been developed.

• **Searching for shapes**—A generally acceptable solution to the problem of interconnection and packaging of subassemblies of integrated circuitry has not materialized.

It is generally agreed that modules with more than one circuit element per substrate are desirable. The upper limit will be determined by a complex compromise of factors such as yield per process, yield per module, encapsulation and packaging, replacement frequency and expense, deterioration due to chemical interaction, tooling costs, quantity to be manufactured, etc. It is unlikely that a single standard module shape will be accepted.

The hybrid approach of combining integrated circuits with more or less standard components is beginning to be generally recognized as necessary for immediate application. This is particularly true where precision resistors, high selectivity, flat response over precisely determined pass bands or impedance transformation are needed.

We have established teams and developed and improved processes. What has actually been accomplished in the development and manufacture of integrated circuits? I prefer not to answer this question but would like to give the reader a check list which may provide a sobering as well as a challenging influence.

The following is a list of functions presently performed in electronic equipment over a frequency range from d-c through microwaves, over a wide range of power levels, and over wide environmental extremes. This list is reasonably complete in that almost any electronic equipment can be built if all functions can be accomplished.

- Frequency generation
- Pulse generation
- Amplification
- Rectification
- Impedance transformation
- Radiation and absorption (antennas)
- Attenuation
- Frequency modulation
- Phase modulation
- Amplitude modulation
- Electromagnetic signal detection
- Electromagnetic signal mixing
- Electrical-to-light conversion (and vice versa)
- Electrical-to-heat conversion (and vice versa)
- Electromechanical conversion (and vice versa)
- Frequency discrimination
- Pulse counting
- Isolation and circulation (unilateral attenuation)
- Amplitude limiting (function generation)
- Bandwidth limiting (filtering)
- Analog addition and multiplication
- Digital addition and multiplication
- Long and short-term signal storage
- Tuning or control of other functions (frequency, bandwidth, attenuation, etc.)
- Frequency multiplication or translation

(Continued on page 86)

1960 Guidance Progress . . .

Notable Gains Made in Gyros, Microelectronics

- *Technology is keeping pace*
- *Hardware progress in gyros*
- *Impact of microelectronics*
- *Lagging accelerometer development*
- *IR scanner accuracy needs improvement*

by Charles W. Benfield*

Development of new and better techniques and equipment for space navigation and guidance has received noteworthy attention during the past year. Seldom have so many attacked a technical problem with so much vigor, enthusiasm, and ingenuity.

The year witnessed some significant hardware progress in gyros—the primary element in precision and reliability in space guidance.

Minneapolis-Honeywell announced start of production on a gyro with a ceramic, self-generating gas spin-bearing. This instrument is 2.75 in. long, 2.182 in. in diameter and weighs half a pound. The company claims a factor of 10 improvement in accuracy and a 30:1 reduction in bearing noise over the gyro's MIG predecessor. The precisely balanced rotor is suspended in its ceramic bearings on a film of gas only 25 micro-inches thick—yet stiffer than the steel ball bearings it replaces.

Jet Propulsion Laboratory is conducting development work of a more exotic nature. A precisely machined sphere, coated with superconductive metal, is supported on a magnetic field at cryogenic temperatures. Thus de-coupled from external torques, the spin axis of the sphere remains fixed in inertial space like the axes of the planets themselves.

Achieving the same result in a different approach, Minneapolis-Honeywell experimentally proved the feasibility of electrically suspending a beryllium sphere in a vacuum. A major program is underway to bring this radically new gyro into production for a shipboard inertial navigation system for *Polaris* submarines. Its applicability to space guidance systems is also being extensively studied.

This device and the JPL cryogenic gyro both hold promise for orders-of-magnitude improvement in accuracy and stability over conventional gyros.

General Electric announced development of a cryogenically suspended, spherically symmetrical rotor wheel spun up by torque coils located in its cylindrical, axial cavity and suspended on a spherical array of magnetic bearings in a vacuum chamber. An experimental cylindrical rotor was spun up to 20,000 rpm with coast-down time of 16 hours. While similar in principle to the JPL gyro, the GE device will be a different configuration, and may possibly have some unique advantages.

Accelerometer development was lagging a bit; there were many exotic dreams of cryogenically or electrically levitated seismic masses, gaseous inertial masses and "chemical" accelerometers—but little new hardware forthcoming. Still dreamed of is a 10^{-15} g threshold sensor for observing minor forces. JPL is developing a miniature quartz pendulum accelerometer.

• **Some leaps forward**—Microelectronics development is paving the way toward realization of the extremely complicated, super-reliable, electronic brains for automatic guidance of space vehicles.

Progress in this area took a surprising forward leap with a number of feasibility models by Westinghouse, including a button-sized, five-watt audio amplifier and a video amplifier dwarfed by a paper clip. RCA's micromodule program has produced working models of whole devices based upon stacks of 0.310" square by 10-mil thick ceramic wafers. Such techniques offer equipment component densities of 250,000 parts per cubic foot. Texas Instruments advertised off-the-shelf availability of a match-head-sized multivibrator.

Microelectronics development programs are well under way at General Electric, Bell Labs., Clevite, Sylvania, Pacific Semiconductor, Fairchild Semiconductor Corp., Philco, Transitron, Honeywell, and many others. As usual, much unpublicized basic research at government laboratories is behind such industrial progress. Talk of 10^{11} components per cubic inch is occasionally heard from the more optimistic participants in serious discussions on the subject.

• **Hardware to come**—Determination of "local vertical direction" and altitude above a planet by infrared is under study by many laboratories. Several horizon scanners have reached the hardware stage, and many disk scanners are on the drawing boards. Present accuracies leave much to be desired.

Hardware solutions are required in this problem area, before a space craft can be brought to a safe landing upon a strange world. The problem of measuring vector velocity relative to a planet is receiving much theoretical attention at JPL and elsewhere.

Star trackers now have over ten years of progressive development behind them, and many companies are studying their adaptation to space navigation. Accuracies to one arc-second are expected to be achieved in working hardware.

IBM and American Bosch Arma have announced progress in miniaturization of high-speed digital computers for space navigation. Both companies are expected to make considerable use of microelectronics developments.

Philco's Dr. Golay has proposed using radio interferometry for accurate distance measurement in deep space.

The Navy's *Transit* satellite program gives excellent promise for a payoff from the space efforts by providing a high-accuracy, all-weather navigation scheme for vehicles on or near the earth's surface. This program is progressing very well indeed; eventually the doppler techniques developed may be applicable to near-earth guidance of spacecraft.

High-precision ground-based radar, working with space-borne transponders, is receiving much attention for tracking and for injection guidance, particularly for near-earth and cislunar operations. It is to be expected that the first manned lunar flights will be closely tracked by radar and notified of their position and velocity by radio.

*Systems development engineer, Minneapolis-Honeywell Regulator Co., Military Products Group

TCM Moves Into Missile/Space R & D

- ***Extended range and measurement capabilities***
- ***New techniques for space***
- ***Low-level multiplexing***
- ***Hybrid-systems investigation***
- ***New components and subsystems***

by Conrad H. Hoeppner*

Telemetry advanced at a faster rate during the past year—and its applications received greater publicity than ever before.

Foremost among the year's accomplishments were extended range, greater numbers and varieties of measurements, and development of more efficient systems.

Transistorization of telemetry receivers is now almost complete, providing greater compactness and reliability.

Pulse code modulation telemetry—already well established in static testing, data reduction and sled tests—has been used for the first time in space vehicles. It is in production for two major missile programs: *Minuteman* and *Titan*. The first PCM ground receiving station for missiles has been installed at the Atlantic Missile Range, following installations for aircraft testing at Edwards AFB, Norair, Douglas and Republic.

PCM telemetry is unique among data handling systems in that it employs "computer language." Data, as it is received, is in a form for direct entry into digital computers for further processing, computations, corrections, plotting and printing. All of the bugs are not yet worked out of these telemetry systems; and advanced PCM system is still under development for Wright-Patterson AFB.

• **Biggest boost**—Probably the most significant adjunct to PCM telemetry systems has been the low-level multiplexer. While this device is not limited in its applications to PCM methods, it is a logical companion to the PCM voltage encoder.

Prior to the development of the low-level multiplexer it was necessary to use an amplifier following each low-level transducer of the thermocouple, strain-gage and resistance-bridge types. These made equipments large, power-consuming and difficult to maintain.

There are now 11 low-level multiplexers in data-processing systems in operation in the Thiokol Utah plant. These operate to a resolution of ten microvolts and a full-scale of ten millivolts. They are subject to errors caused by temperature changes and vibration, but are being developed to appear soon in aircraft and missile test programs.

• **The new challenge**—Telemetry has been forced to expand its scope to accommodate the new demands for scientific data. Mainly used heretofore for measuring temperatures, accelerations, positions, motions, and electrical characteristics internal to missiles and aircraft, it is now being employed to explore space.

The measurement of radiation density, ion density, atmospheric composition, visible and ultra-violet light, magnetic fields, particle impacts and the transmission of photographs, have required new transducers and also new data conditioning equipment to "normalize" the measurements for transmission over telemetry links.

There have been new demands on the telemeter for handling greater quantities of data with greater accuracy over longer distances. In many cases this has led to pre-transmission processing and reduction of data.

• **Thinking revolution**—A three-year comprehensive study of telemetry methods and systems sponsored by the Department of Defense has been completed. This study was unusual in the fact that measurements were made to decide upon controversial assumptions for calculations. Many of the results revolutionize thinking along certain lines and have revised previously established standards.

A conclusion of the report was that a combination pulse amplitude modulation and pulse code modulation system would prove most useful for future military test applications. The PAM portion would be used for low-accuracy data and the PCM high-accuracy data.

Needless to say, such a system is not now in use; its advent would make obsolete many millions of dollars worth of telemetry equipment now installed in test sites throughout the country.

Other noteworthy developments:

• The Telebit system of variable bit rate, allowing exchange of information speed for transmission distance.

• Wide-band recorders for recording on magnetic tape the greater information rates provided by modern telemeters.

• Use of large receiving antennas even at high frequencies to enhance the telemetry signal. One system at Vandenberg AFB employs omni-directional direction-finding antennas used in conjunction with extremely narrow band receivers to point the large telemetry antenna in the proper direction—a problem which becomes more serious as the size of the receiving antenna is increased.

• Use of light diffraction and optical filters to simulate electrical filters employed in data separation, interpolation, and extrapolation. An extremely precise filter characteristic is applied to a very large number of data channels by a relatively small and simple device. Methods are being explored to permit its use in actual data systems.

It is also heartening to note the gradual infiltration of government-developed telemetry techniques and equipments into American industry. The dissemination of information about telemetry is much slower, however, than the passage of information through the telemetry system.

Telemetry has moved in to investigate the destructive effects of wind-induced vibration to electrical transmission lines and telephone lines. Applications to mobile equipment, rotating equipment, flaw-detection and sensing portions of industrial process control are just beginning.

One of the leaders in the military telemetry field, for instance, has entered into a royalty agreement which permits a newly formed commercial organization to apply its developments to industrial applications. Equipment developed by this company will be supplied to the electric utility industries and to the medical field.

**President, Electronics Corp., Chairman, IRE PGSET, and Member of M/R's Editorial Advisory Board.*

Instrumentation . . .

Range Accuracy Poses New Challenges

- **New guidelines for progress**
- **Microwave systems**
- **New frequencies, techniques**
- **Improved equipment**

by W. C. Wootton, Jr.

Secretary, Inter-Range Instrumentation Group

NEW GUIDELINES established during the past year set the stage for future developments in telemetry and range instrumentation. It is evident that although significant progress has been made in the recent past, the most significant is yet to come.

The final report of the Aeronutronic telemetry study, released in early 1960, provided industry with the guidance it had awaited.

And another important direction developed in May, when the 1435-1535 mc radio frequency band was endorsed anew for missile telemetry used by the Inter-Range Instrumentation Group (IRIG) and Aeronautical Flight Testing and Radio Coordinating Counsel.

• **Pulse code modulation**—To meet the need for increased accuracy and more efficient operation, PCM telemetry systems are being developed. Many of these, especially those for Air Force projects, have unique characteristics and do not meet standards recommended by the Aerospace Industries Association or IRIG for PCM telemetry systems. Picatinny Arsenal and several others, however, are developing standard PCM systems for use on the missile test ranges.

Contrasting the PCM developments are several systems being developed to instrument the *Saturn* booster. One of these is a 216-channel PAM-FM-FM system. The other is a frequency deviation system with a high data bandwidth capacity.

Pulse amplitude code modulation (PACM) as opposed to PCM was recommended in the Aeronutronic study report for future missile telemetry operations. In this system the PCM signal is amplitude modulated with additional channels of analog data. Size and weight are slightly greater than that of a PCM system alone, but efficiency is increased without appreciably changing the radio-frequency requirement.

PAM channels are used where requirements exist for medium accuracy (1% error) analog channels. The PCM channels are provided to meet high accuracy requirements or where it is desired to use digital techniques. It is believed that variations of PACM-FM will effectively meet the majority of future missile telemetry requirements.

• **Microwave systems**—The need to move missile telemetry operations out of the VHF telemetry band (216-260 mc) by 1970 has prompted work on systems that would operate in the microwave frequency region. A development model of a 2200 mc transmitter was built recently by General Electronic Laboratories under an Air Force contract. Another airborne unit designed to operate at 2200 mc was built by Spectralab Instrument Company and turned over to the contracting agency at White Sands Missile Range for evaluation.

While these recent developments have been encouraging, even greater hope is held for the 1435-1535 mc band where airborne package size can be reduced. It is believed that developments in these microwave bands must be continued at the fastest possible rate if a reliable and operational system is to be available by 1970.

Ground station equipment compatible with the new airborne units is also being developed. Examples are the fabrication of a 2200 mc traveling-wave maser capable of being mounted on the rear of a parabolic dish, and Radiation, Inc.'s development of a 2200 mc correlation detection receiver.

• **Receivers, antennas, and transducers**—Several of the national test ranges have sponsored receiver improvement programs and emphasized the development of optimum capability for PCM and time-multiplexed signals. Since much effort has already gone into receiver front end improvement, emphasis is now being placed on the detection process.

A number of automatic tracking antennas have been developed to meet the growing need for this type of antenna in both space and missile testing. These generally have relatively high gain and can be used as acquisition aids to other instrumentation systems, in addition to their use in the telemetry system.

A Users' Symposium on Telemetry Transducers was held for the first time this past year, to review transducer development effort, both in the United States and abroad. It was apparent from this meeting that additional effort was needed to standardize transducer terminology and to establish calibration and testing procedures. To this end the National Bureau of Standards Telemetering Transducer Group has been working to develop test methods for dynamic testing of transducers, while Wright Air Development Division has been working to standardize testing and calibration procedures.

• **Studies and reports**—Many study and evaluation reports on telemetry have been released recently. These include "The Case of FM-AM Versus FM-FM Telemetry" by Dr. L. L. Rauch, for Wright Air Development Division; a number of reports by Naval Ordnance Laboratory at Corona; a number of Naval Air Development Center reports; and an IRIG Recommendation, No. 101-60, "Magnetic Tape Recorder/Reproducer Standards for Telemetry Applications."

AF Does Something About Reliability

- ***Reliability and maintainability biggest challenge***
- ***New programs for configuration control, commercial equipment use, calibration standards, understandable maintenance data***

The Air Force in the past year has been doing something about those much bandied-about words in Ground Support Equipment—reliability and maintainability. This is the word from the Aircraft and Missiles Division, Chief of Staff for Materiel.

It's being accomplished through new and strengthened programs in configuration control, buying commercial equipment when it will do the job, setting up calibration standards, and getting technical data for the field maintenance airman in a form which he can understand.

Within the past two months, even a definition of GSE has been adopted to take some of the confusion out of the many terms used in the field.

Since management problems are often best resolved by the application of management techniques rather than by developing new definitions, Air Force has settled on this GSE definition:

"Any or all implements or devices which are required on the ground to make a weapon system, support system, control system, sub-system or equipment operational in its intended environment. This includes all equipment required to install, launch, arrest, guide, control, direct, inspect, test, service, adjust, calibrate, appraise, gauge, measure, repair, overhaul, assemble, disassemble, handle, transport, safeguard, record, store, actuate, maintain or operate the system, sub-system, end item, or component. This definition applies regardless of method of development, funding or procurement."

• **Maintainability through standardization**—With the end goals of using less manpower, fewer tools and the minimum in supplies and logistics, Air Force is striving for optimum standardization of ground support equipment, realizing that in many instances full standardization is not possible.

Such optimum standardization holds true for the whole gamut of GSE —transport/erector vehicles, materials and fuel handling equipments, launchers, electronic check-out and data processing systems.

With more standardization, Air Force feels better maintainability will be the result. With this working philosophy, many directives and instructions are being pointed toward the design engineer to have him design equipment which can be maintained with minimal effort and cost.

In this effort, Air Force is practicing what is termed configuration control. For example, it doesn't want 100 fork lift trucks of five or more configurations, but rather, 100 of the same configuration.

This, in turn, has lead to increased purchasing of commercial equipment when available without designing new varieties. For instance, in recent months the trend has been to get away from using military engines in some vehicles and purchasing commercial types when available.

• **Boiling down data**—In the complex GSE field, Air Force is also taking a long hard look at contractors' preparation of technical data for equipment maintenance.

"Our fault is that we've gone overboard with an excessive amount of data and have lost sight of the man who must use this data to maintain a particular piece of equipment," one officer commented. Biggest problem is to get the data out of the PhD class, and make it simple, readable and understandable.

Previously, Ballistic Missile Division had responsibility for technical data in the missile programs. It has now been moved to Air Materiel Command, which is reviewing all specifications and formulating revisions to make it more usable in the hands of the technician.

• **One system of calibration**—In still another area—calibration support for missile systems—the Air Force has realized there has been a lack of uniform action in the establishment of calibration and repair facilities for base precision measurement equipment, particularly with respect to the support of contractors during the installation and checkout phase.

This has been because separate contractor facilities have been established at some missile bases while, at other locations, Air Force commands had made arrangements for the base calibration facility to be used in support of the contract.

The Air Force accordingly has ruled that the establishment of separate missile base contractor installation and checkout facilities for calibration and repair of precision measurement equipment is not in its best interests and will result in unnecessary expense.

So the Air Force's calibration system, rather than separate industrial systems, will be used exclusively. One reason: the Air Force feels that its operating personnel can get valuable experience and training when they recognize the exact calibration needs of a particular weapon system at an early date.

Further, a single source for standards of known accuracy with respect to the National Bureau of Standards will be available. Since the same source will be used during and after installation and checkout phase, no post inspection-and-checkout phase operational difficulties should arise due to differences in contractor-versus-Air Force calibration systems.

In one ballistic missile program, Air Force discovered that the unusual large amount of R&D GSE left over when phasing into the operational system required some 13,000 calibrations. This has since been reduced by some 40%.

1960 Materials Progress . . .

Foundation Research Speeds Ideas for Navy

- *BuWeaps program stimulates scientists*
- *Eliminates ponderous decision processes*
- *Makes individual responsible—and saves money*

by John F. Judge

The Navy is cultivating Missile Age ideas through a unique, red-tapeless program—Foundation Research.

Initiated about 10 years ago in the old Bureau of Ordnance, the program spread to the Bureau of Aeronautics in 1957. Since the two bureaus merged to form the current Bureau of Weapons, the Foundation has become an $8-million-a-year idea mill.

Bureau officials couldn't be happier with the results.

The original objective was twofold—to give the individual station money to exploit the promising ideas of its employees, and to create an attractive working atmosphere. Both purposes are being fulfilled.

The effect on the morale of the scientists is reflected in the high retention rates of the various laboratories.

Originally the funding was allocated as a definite fraction of the annual budget of a particular station. Now money is distributed in proportion to the possible contributors of new ideas. The amount is still less than 5% of a station's total budget.

Each station involved in the program administers its own funds.

• **Streamlined routine**—In operation, the program begins with an idea or a suggestion from an individual. The proposal is submitted to a small board composed of the installation commander, the chief scientist, and the laboratory, or project directors.

The proposal is rated for merit; if it is approved, initial funds are allocated for the program and the scientist goes to work. Many such projects are subsequently removed from the Foundation and funded under supporting research. Still others begin and end within the Foundation—supplying needed information and data for present or future use in allied fields.

For a long time, no formal reports were required. But they were encouraged—for fiscal ammunition if for nothing else.

The bulk of the projects are basic in nature. Some, which concern weapons systems, are classified, but the majority are published in various forms.

Foundation research led to over 300 such published papers from the Naval Ordnance Laboratory at White Oak alone.

One classic idea resulted in the air-to-air *Sidewinder* missile. Another, now being pursued at the Naval Air Material Center, Philadelphia, has attracted national interest. M. J. Devine's work in solid film lubricants is being closely watched by both government and industry.

Computers are being redesigned or created from scratch. The miniaturization of antennas is another fruitful area.

A striking example of the effectiveness of the Foundation Research idea is the current program at the Naval Air Materials Center. In one year the grants there rose from $41,000 for three projects to $310,000 for 15 projects.

The wide range of disciplines involved can best be illustrated by describing some of the areas covered by the researchers.

• Statics and dynamics of fluids—to provide a theoretical basis for the solution of hydraulic, hydrodynamic and gasdynamic problems.

• Hydrogen embrittlement—knowledge of the mechanisms problems of hydrogen embrittlement and the embrittling characteristics of a deuterium bath.

• Plastics, elastomers and fibers—research and development of organic metal-cordination polymers possessing exceptional thermal stability, gamma radiation resistance and strong mechanical properties.

• Solid film lubrication—Determination of the mechanisms by which metal surfaces are lubricated by solid films and to provide a definite working theory. Investigation of lubricity as a function of solid structure, particle size, film hardness and lubricant-bearing reactivity. This is the study that aroused national interest.

• Radiant heating—Determine the effects of infrared heat on the structural efficiency of aircraft and missile components and to correlate the laboratory and flight test effects with true aerodynamic heating.

• Brittle metal effects—Determination of the role of oxygen in the brittle behavior of metals. The study is aimed at understanding the effect of such behavior in the refractory metals.

• Energy absorption—Obtain fundamental information on energy absorption materials for the general purpose of improving the state of the art. There are an increasing number of developments in which, if energy is added to a device, a certain portion of this energy is absorbed or reconverted at the end of the cycle. *Polaris* missile recovery is one such development.

• Heat—Developing methods for measuring the heat of interior and exterior surfaces of aircraft and missiles undergoing constant changes in heat conditions and thermal shock. This study is directed toward answering a need for heat measurements under materials such as fiberglass, ceramics and thin specimens of honeycomb construction.

• Strain gages—Definition of the areas of future effort in the elevated strain gage field.

• Polyamide polymers—effects of exposures to ionizing, ultraviolet and thermal radiation.

Besides NAMC and White Oak, stations included in the program are: Naval Ordnance Testing Station, China Lake, Calif.; NOL, Corona; Naval Weapons, Dahlgren, Va.; NUO, Newport, R.I.; NAL, Johnsville, Pa.; Naval Missile Center, Point Mugu, Calif.; and the David Taylor Aerodynamics Laboratory near Washington, D.C.

Expenditures involved are small in comparison to the net worth of Foundation Research. Dr. Edward S. Lamar, Chief Scientist, Research, Development, Test and Evaluation, BuWeaps, points out that no good ideas ever came from a full stomach. The basic principle is to keep the researchers a little hungry—and emphasize brainpower rather than chrome-plated equipment.

1960 Space Medicine Progress . . .

Augmented Field Ready to Expand

- *USAF, NASA, industry boost the science*
- *Solar flares found hazard to space travel*
- *Instrumenting animals for flight tests*
- *'Bathtub' research on weightlessness*

by Lt. Col. David G. Simons and Dr. Hubertus Strughold*

A firm groundwork has been laid for an expanding aerospace medical activity during the past year. On three fronts—military, civilian and industrial—new organizations have been created or augmented and put into operation.

Organized this past October, the Air Force Aerospace Medical Center, located at Brooks AFB, San Antonio, united under one command USAF's School of Aviation Medicine, Epidemiological Laboratory and the Medical Service School. This integrating move shows the growing importance of aerospace medicine to the Air Force. Further evidence is that Congress has authorized an $8-million building expansion program at the facility.

In the same vein, it is notable that early this past March the Office of Life Sciences was created by the National Aeronautics and Space Administration. Heading it is Dr. Clark T. Randt.

This office formed the fifth major division of NASA and ranks equally with the offices of space flight programs, launch vehicle programs, advanced research programs, and business administration.

The ambitious program of research in all aspects of space biology and medicine outlined by Dr. Randt for his office is matched by the decision of most major aircraft companies to establish a space medicine research group. Thus the growing base of space medicine research is being widened further by the appearance of such groups in Boeing, Martin, Northrop, North American, Douglas, Lockheed, Convair and Chance Vought.

• **Solar flares a problem**—Satellite, balloon and space probe experiments have clarified the radiation hazards to be expected in manned space flight. It is known that the core of the inner Van Allen radiation belt maintains a steady radiation intensity. *Explorer VII* has now clearly demonstrated the variable nature of the outer Van Allen belt. This variation was particularly evident for the ten days following the large magnetic storm of this past March 31.

Early this past spring, many exciting results significant to space medicine came from *Pioneer V*. The vehicle was about five million miles from earth and it was a time of intense solar activity. It was learned, for example, that the well-known cosmic radiation disturbance called a "Forbush decrease" occurs on a solar, or galactic scale. It is clearly unrelated to terrestrial influences.

This finding serves warning that variations in cosmic radiation intensities may occur during space flight, resulting from galactic disturbances encountered by the sun in its path through interstellar space.

Balloon studies conducted over Minnesota together with the *Pioneer V* data confirm the growing suspicion that solar flares represent a major radiation hazard during interplanetary travel. In order to reduce a "typical" flare exposure to an acceptable 10 Rem (roentgen equivalent man) within a four-foot radius living compartment would require a calculated 10,000 pounds of carbon.

From an early report from *Pioneer V* it was discovered that a ring current of about five million amperes circulates at a distance from 7 to 13 earth radii from us. This current represents a radiation hazard of undetermined magnitude. However, the likelihood that the current is composed of low energy particles is encouraging.

The Russian *Lunik II*, which approached the moon last September, reported no radiation belts corresponding to the Van Allen belts surrounding the moon. This is good news to prospective space travelers.

• **Monkeys instrumented**—This past December, NASA's *Little Joe* rocket flight to test the *Mercury* capsule recovery system under the most adverse dynamic flight conditions included two SAM monkeys. The subjects were painstakingly instrumented through several techniques new to space flight animal experimentation.

An eye-motion detector which sensed the changes in voltage distribution resulting from eye motions recorded the occurrence of nystagmus—the sweeping eye motion produced by motion sickness and other disturbances of equilibrium. These sweeping motions were observed during the period of high accelerations which occurred in all three axes during the emergency escape phase of the test flight. These continued through the short 20-second interval of weightlessness.

The psychomotor task test, which required the animals to pull a lever in response to a flashing light, showed a marked loss in performance during the acceleration and weightlessness phase. The vectorcardiogram, an advanced technique for indicating the electrical vector forces produced by the muscular contractions of the heart, revealed significant changes during the same acceleration and weightlessness phase.

• **Two-man crews okayed**—The initial run of SAM's two-man space-cabin simulator in March confined two Air Force volunteers in a reduced-pressure, oxygen-enriched atmosphere. They were completely isolated for a 14-day period. It was found that the important weight-saving measure of distilling waste water for all non-drinking purposes proved acceptable and practical.

The experiment also showed that the assumed rates of water loss through respiration and sweating under reduced pressure conditions are significantly in error when applied over this period of time.

The usually proposed nutritional energy requirements of approximately 3000 calories per man per day appear to be significantly lower, approximately 2200 to 2500 calories.

The fact that no major psychological disturbances were observed points to the feasibility of two-man crews for space missions of durations on the order of two weeks. Crews of this size are desirable for work scheduled and mutual emotional support considerations.

A major question concerning the

(Continued on page 92)

**Col. Simons is chief of the Bioastronautics Branch, USAF School of Aviation Medicine. Dr. Strughold is Professor of Space Medicine and Advisor for Research at USAF Aerospace Medical Center, and an M/R advisor.*

A Crisis in Electronics Standards

Meeting sponsored by NBS and AIA notes emergency created by lack of standards for higher frequencies and begins search for answers

Lack of national electronic standards for new higher radio frequencies is causing confusion, excessive delays, and loss of money for both industry and the national defense program.

This was pointed out at the recent 1960 Conference on Standards and Electronic Measurements at National Bureau of Standards Boulder Laboratories by Lloyd B. Wilson, chief of the primary standards lab of Sperry Gyroscope. He said that military needs and the space program are requiring accuracies of measurement unheard of a few years ago and for which calibration instruments do not exist.

The Conference is the first of a series of measurement research conferences between industry and NBS initiated by Aerospace Industries Association to probe each field of measurement in depth to determine which needs are most urgent and how they might best be met.

The AIA-NBS conference was the first to provide a discussion of mutual problems between the men who develop electronic standards and those who use them. Industry personnel represented firms who had indicated that they particularly needed better standards for measuring microwave power and attenuation. NBS representatives included project leaders and section chiefs who are responsible for developing standards and measuring methods and providing calibration services.

As revealed at the conference, NBS Radio Standards Laboratory has made dramatic progress in developing new standards. Examples: A technique for measuring small attenuations to accuracies exceeding one ten-thousandth of a decibel and a microwave standard of power at X-band frequencies that has been the world's most accurate to date.

It was pointed out, however, that the Laboratory has been swamped by the needs created through the amazing growth of electronics during the past decade.

• **Where standards fall short**—A primary purpose of the meeting was to suggest action which might be taken by NBS, the electronic industry, military, and scientific organizations to help meet the emergency. That an emergency exists was confirmed by specific situations reported at the conference:

• The million-dollar development of radomes is proceeding more by trial and error than through test and analysis because precise phase and amplitude measurements do not exist in the required frequency range.

• One firm has to use its precision measurement laboratory facilities to test sections of coaxial cable from the production line since adequate production-line standards are not available.

• Klystron tubes—used to generate high-power signals for radar detection systems—are being over-designed just to be sure that they are powerful enough to do the job. This is necessary because there is no way to precisely measure the peak microwave power generated by these tubes.

• The performance measurement of modern radars requires the testing of many new and complex items of equipment. Quite often the radar is considered to have failed when the fault was within the test instruments.

(Continued on page 82)

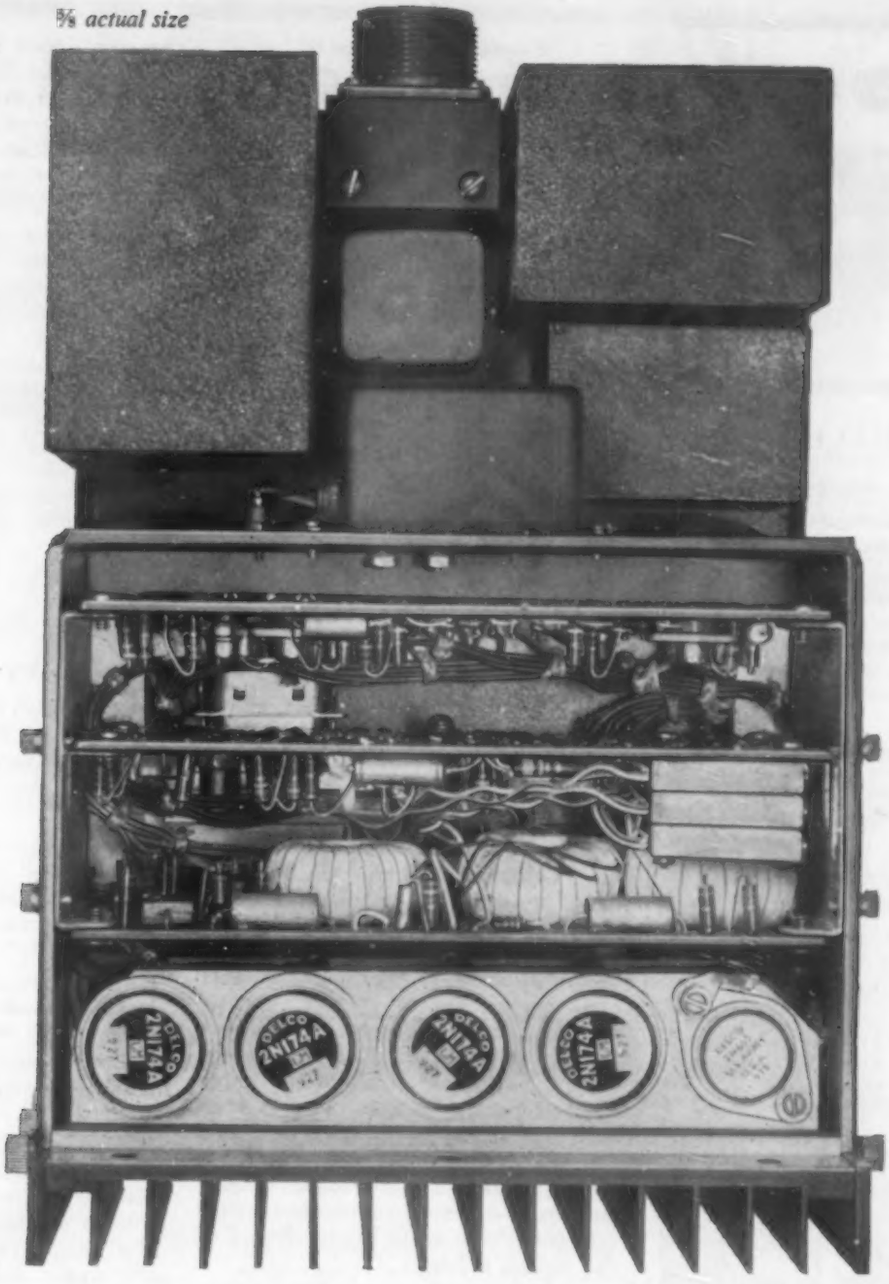
Avco Builds Record Noise Generator for Sud

This acoustic noise generator—capable of producing the highest sound pressure level ever achieved in a large-capacity reverberant chamber—has been delivered to Sud Aviation by Avco-RAD, Wilmington, Mass., designer and builder. The French aircraft/-missile firm will use the noise facility to test components and systems in its research center in Cannes, France.

The rocket-engine noise simulator pumps 146 decibels into a 200 cubic foot pentagonal reverberant chamber where individual octave band sound pressure levels can be maintained within ±3 db with a specimen as large as 20 cubic feet.

The generator covers an audio frequency band from 37 to 9600 cps with 36 noise generators and 21 power amplifiers. Noise levels as high as 170 db can be produced at discrete frequencies.

⅓ *actual size*



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(Continued from page 80)

• Measurements of microwave power, for example—made on different days by the same equipment—will disagree by 50%. Yet, as one speaker pointed out, some radar systems are operated close to breakdown and it is necessary to hold a given power level to keep a system operating. Under such conditions, a 5% error in measurement becomes the difference between operating and not operating.

The meeting revealed what is possible now in microwave power and attenuation, and NBS obtained a better idea of what accuracies are most urgently needed. Discussions indicated that in a few cases NBS can provide interim standards—even within current facilities—that will be a great help to many users.

As an example, NBS currently provides calibrations of microwave power measuring instruments between 8200 mc and 12,400 mc. By using different techniques, calibration can be extended to lower frequencies in the near future. This service will provide somewhat lower accuracy but will help meet many of the immediate needs expressed at the conference.

• **Equipment lacking**—On the other hand, however—even though the techniques are known—many standards cannot be extended to new frequency ranges because of lack of personnel and equipment.

For instance, an urgent need exists for the extension of a current microwave attenuation standard to three higher frequency ranges. Yet, to evaluate this technique at even one new frequency range in the millimeter wave region requires $11,000 worth of new equipment—more than the present total annual equipment funds allotted to the project involved.

Dollars alone are not the answer. NBS representatives were asked to estimate how long it might take—at today's activity level—to develop minimum acceptable standards which do not presently exist for the frequencies (up to 100 gigacycles) and quantities most needed today. Based on many unknowns, the estimates—varying with measurements involved—ranged from five to ten years for most quantities. And an increase of several times the current budget would shorten this delay no more than half, according to NBS. The main time delay would be the hiring of capable personnel and their initial training.

Estimates make no provision for the new needs which will arise and must be met during the next few years.

Participants agreed that it is frequently difficult to discover whether an expressed need is realistic. Examples were given of "impossible" accuracies specified to "play safe." They further agreed, however, that most of the stated accuracies described at the conference are really and urgently needed.

AIA industry representatives were asked to state not only what was needed but also why this was required —to help estimate the urgency of the needs. NBS described for each field the state-of-the-art in research, development, and calibration. From discussion of the presentations, tentative recommendations evolved for action by the Bureau, industry, the military, and scientific organizations. These will be carefully reviewed by AIA and then officially presented to the groups involved.

Niobium Oxidation Cause Isolated by NBS Studies

The oxidative behavior of niobium —a potential high-temperature structural candidate—has been studied in detail at the National Bureau of Standards.

The oxidation problem is caused by the continual nucleation and growth of porous niobium pentoxide—which incessantly presents fresh metal surface to oxygen.

Investigators at NBS oxidized niobium specimens under controlled conditions in a sensitive vacuum microbalance. Examinations after different periods of oxidation led to the discovery.

Electron diffraction patterns of the initially formed oxide showed certain features of both niobium oxide and niobium dioxide. Although little or no change occurred in the predominant interference color, indicating that the film thickness remained constant, a continual increase in weight showed that oxygen was still being absorbed by the system.

Pentoxide globules form beneath the initial film and push upwards until the film's tensile limit is reached, rupturing the original oxidation film.

The globules coalesce into a continuous, porous layer which increases in thickness. The metal surface is continually exposed to oxygen because the large volume increase which accompanies the conversion of niobium to its pentoxide hinders the formation of a stable interface between the metal and the pentoxide. The reaction becomes a surface reaction of constant rate and rapid oxidation results.

The study was sponsored by the Air Force Office of Scientific Research.

3M Materials Memo

News of materials for the aerospace industry... selected from the 27,000 products of the 3M Company

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The whole secret lies in their unusual construction. They're made of a transparent thermoplastic material filled with silicone grease and use metal finger-like connector elements, built into a top closure button. The cut wires are inserted into the sleeve of the connector and the button closure is squeezed into the body of the unit, using a special crimping tool. Depressing the button removes the wire insulation, grips the conductors, insulates the joint, and provides a positive seal for the silicone grease. Thus, a complete splice is made in one operation, involving no stripping, twisting, soldering or insulating. And visual inspection of the joint speeds up quality control, too.

"SCOTCHLOK" UR connectors can handle any two or three wire combination of #19 to #26 AWG solid or #20 to #26 AWG stranded wire. They can be used virtually anywhere a splice is made and on nearly every type of wire used in the communications industry. This would include wires insulated with miscellaneous plastics, paper, enamel, rubber, Teflon, or other materials. Your local Electrical Products representative will be happy to show you how "SCOTCHLOK" connectors can literally put your operations on a push-button basis.

■ A case of non-support

A flame would have a tough time surviving if it had to depend on 3M's new printed circuit board construction. Designated as "CUCLAD" #6097, this newest member of a range of printed circuitry materials offers some really distinguishing (or perhaps we should say extinguishing) features. Containing special flame retardant additives in its laminated glass cloth-epoxy backing, this "CUCLAD" board offers a high degree of flame retardance without the usual brittleness. This means easy machining with little waste. In actual test, the flame extinguishes itself in one to two seconds after the torch is withdrawn.

No. 6097 includes qualification to Mil-P-18177B Type GEB and NEMA grade G-11; is available with one or two ounce electrolytic grade copper foil bonded to one or both sides. This bond offers a peel strength as high as 11 pounds per inch and is resistant to standard plating and etching solutions. What's more, it offers you the option to either standard dip or float solder the finished circuit. "CUCLAD" #6097, a versatile performer, is made more so by coming in a broad thickness range of from 1/64″ to 2″ in individual sheets, 36″ x 42″.

If printed circuitry is a burning issue with you, why not have your local MICA INSULATOR DIVISION representative give you more information on this exciting product—or fill in the coupon below.

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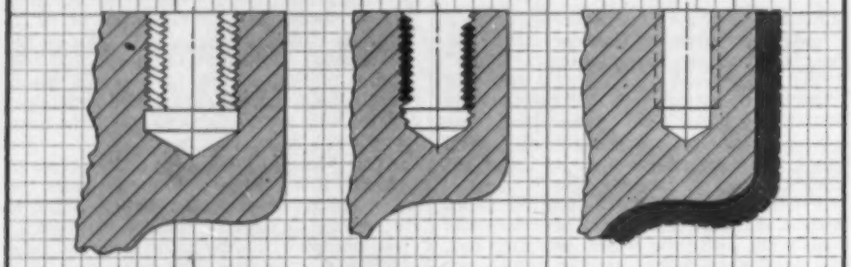
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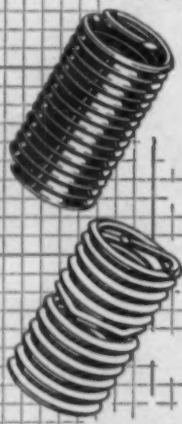

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PROPULSION

(Continued from p. 71)

advantage because the volume will reduce the unit cost of tooling up. But Mitchell said fiber glass and plastic cases are cheaper when small numbers are involved. He contended that the lightweight material could not be ruled out even for the largest conceivable solid rockets.

The NASA propulsion chief voiced enthusiasm for the Air Force Project *3059* plan to explore the feasibility of a very large solid motor, on the order of a million lbs. thrust. He said:

"We in NASA are extremely interested and fully understand the need of getting as much data as necessary to determine where a large solid booster fits into the space picture. We are following and participating in the Air Force plans very closely."

• **Nuclear rocketry**—"In the last year, we have seen the transition of nuclear rocket propulsion from essentially a loose research effort and a reactor program to a much firmer and essentially a defined program with a firm development objective—a flyable nuclear engine."

Mitchell recalled that NASA officials have said a test is scheduled for 1965. "This is becoming a major area of buildup of effort," he added.

Mitchell said the joint NASA-Atomic Energy Commission work is making excellent progress—particularly in work on the reactor, the feed systems and the hydrogen turbine pump.

• **Electrical propulsion**—The last year has seen marked increases in R&D efforts by government agencies, non-profit organizations and industry on electrical devices, Mitchell asserted. As a sign of the progress made, he cited decisions by both NASA and the Air Force to develop ion engines. "We hope that in a year or so these engines will have demonstrated a reasonable operating time."

The engines are to develop 0.1 lb. thrust and draw 30 kilowatts of current from a SNAP-8 nuclear powerplant. Total weight of the system, including the thrust device and powerplant, will be a few thousand lbs., he said.

Progress in ion devices has included reduction of interception of ions by accelerating and focusing electrodes, and increases in power conversion efficiency (ratio of Kinetic power in the thrust beam to total power input).

A critical problem still remaining is beam neutralization, he continued. "We are obtaining better insight on this problem but I don't think we have any clear experimental data as yet to indicate whether it can be accomplished."

Pioneer V Found Radiation Peril Past Van Allen Belts

Radiation will be a major hazard for man throughout the zone between the earth and Venus—not just in the Van Allen belts.

This is the most important finding of *Pioneer V*, the U.S. space probe that was tracked and telemetered for 108 days to a distance of 22,462,740 miles from Britain's Jodrell Bank radio telescope.

Man in space beyond the Van Allen belt will need extensive protection from the radiation in solar flares, Dr. Abe Silverstein reported last week.

Silverstein, director of the Office of Space Flight Programs, National Aeronautics and Space Administration, made his estimate at a press conference called by NASA to report on the end of efforts to communicate with the 94.8-lb. planetoid now swinging in a solar orbit between those of the earth and Venus.

Silverstein gave no figures on radiation intensity. However, in a paper given before the American Geophysical Union on April 29, three physicists headed by J. R. Winckler of the University of Minnesota reported that intensity can rise as high as 30 or 40 roentgens per hour during a magnetic storm.

Without shielding, a half-day's exposure at such a level would be lethal for about half of the persons exposed, according to the calculations of the National Committee on Radiation Protection.

The report on *Pioneer V* was given after NASA Administrator T. Keith Glennan presented a model of the space vehicle to Dr. A. C. B. Lovell, British astronomer and director of Jodrell Bank, in recognition of the cooperation of the staff of the 250-ft. dish antenna.

Silverstein listed these other scientific discoveries realized during the *Pioneer V* flight:

- An interplanetary magnetic field exists. Its intensity fluctuates in relation to solar flare activity.
- A ring current of five million amperes, 25,000 miles in diameter, exists at 40,000 miles from the earth.
- The earth's magnetic field extends at times out to 65,000 miles and oscillates with solar flare activity.

Pioneer V, launched from Cape Canaveral at 8 a.m. (EST) on March 11, sent intelligible signals with its 5-watt transmitter on command until 7:33 a.m. (EDT) on June 26, at which moment it was traveling away from the receiving antenna at 18,621 mph and had traveled 60% of the distance that separates the orbit of earth from the orbit of Venus. At the time, it was 78.9 million miles from the center of the sun.

- **A flock of firsts**—Silverstein said its technological firsts included the greatest range over which man has maintained control over an instrumented vehicle, the greatest range over which man has tracked a man-made object and the first instrumented space laboratory making measurements of the interplanetary magnetic field, the plane of the magnetic field and total flux and energy level of radiation in interplanetary space.

Also, Silverstein said, *Pioneer V* established a record in the distance at which an interplanetary guidance system was used. He explained that the vehicle had Doppler capability for measuring position in space, which are parts of advanced guidance systems to be used in future space vehicles.

Other scientific achievements, he continued, include the first measure-

(Continued on page 95)

from the smallest to the largest missile part . . .

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CIRCUITRY

(Continued from p. 73)

• Switching

I would further point out that, in order to perform these functions, we have found it convenient, if not necessary, to generate, transmit, control and store electrical energy in the forms of electrical current, electrical flux, magnetic flux, and electromagnetic wave flux.

Semiconductor devices provide control of current; magnetic and dielectric materials, such as thin magnetic metallic films, ferrite and ferroelectric ceramics, will provide the control of the other three forms. This fact adds to the incentive for inclusion of electronic ceramics and thin films in the four technologies mentioned in the introductory paragraphs.

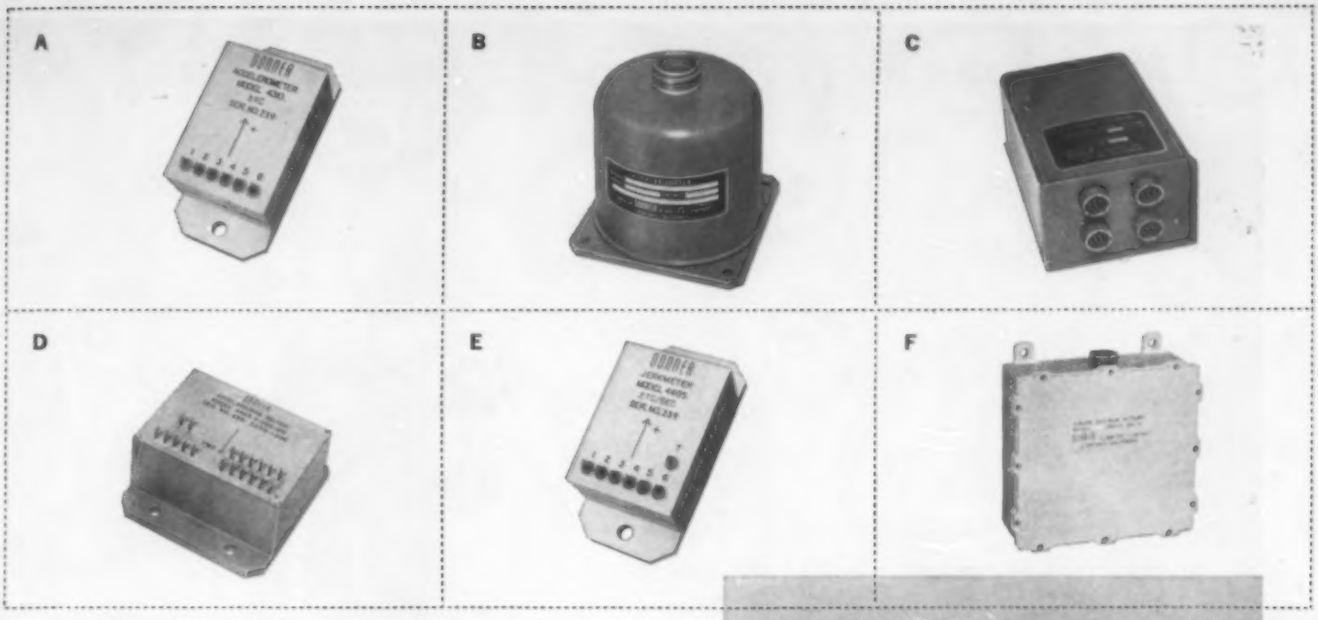
Substantial progress in integrated circuits will be achieved when we have performed all of the functions listed above over a range of frequencies, power levels, and environments. We must have succeeded in processing the four forms of electrical energy in a variety of circuits. The uninhibited approach of "Tell me the function you want performed and I'll invent a way to do it," is not practical for the accomplishment, in two or three years, of everything we have been able to accomplish in 40 years of development of the electronic art.

It is important to realize that we are not starting over but improving our techniques for production in order to meet the problems of greater restrictions on size, cost and power consumption, increased demands on reliability and speed, and new environments. The effect on the electronic materials, components, and equipment manufacturing industry will be far-reaching but gradual. We have ample time to act if we are alert to the new developments.

'Rotochutes' Will Attempt To Slow Re-entry Vehicles

Experiments with helicopter-like rotating wings to slow down and guide fast-moving re-entry vehicles to a landing will be conducted under a $448,000 Wright Air Development Division award to Kaman Aircraft Corp.

In the first phase of the contract, Kaman will employ its "rotochute" to attempt to land a 200-lb. package released at subsonic speeds from 50,000 ft. Recovery of much larger packages released at supersonic speeds from extremely high altitudes will be tried later on. The rotochute has two spring-actuated rotor blades which are motor-driven after snapping into position.



A. Model 4310 0.1% Linear Accelerometer. B. Model 4525 Angular Accelerometer. C. Model 4710 Integrating Accelerometer. D. Model 4403 Acceleration Switch. E. Model 4405 Jerkmeter. F. Model 7005 Airborne Analog Computer.

A Short Guide to Donner Scientific

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Model 4310 0.1% Linear Accelerometer—This high output, high resolution transistorized accelerometer is designed for demanding measurement and control applications met in telemetry, gyro-erection, programming, and short range inertial guidance.

Key specifications: non-linearity plus hysteresis, within 0.05% deviation from best straight line; standard ranges, between ±0.05 g full range and ±30 g full range; resolution, better than 0.0002% full scale; weight, 3.5 ounces; standard output, ±7½ v dc and/or ±1.5 ma full scale; options, biased output, liquid filled units, and/or 28 v dc operation; 0 to 5 v dc output; price, standard unit, $450.

Model 4525 Angular Accelerometer—Chief applications for this unique force balance accurate angular accelerometer are closing the servo loop on ground launching equipment for missiles, detecting roll, pitch and yaw acceleration once they are airborne, and measuring induced angular acceleration when a missile is vibrated by a linear shaker.

Key specifications: ranges, from ±2 radians/sec² to 50 rad/sec² or any intermediate grouping; frequency responses, essentially the same as that of a linear second order system; nominal full scale output, ±20 volts; resolution, 0.01% full scale or better; linearity, 0.1% of full scale; hysteresis, less than 0.01% full scale; damping, 0.6 ±0.1 of critical; size, 3.7" diameter x 3.7" high; available in nitrogen filled and liquid damped versions.

Model 4710 Integrating Accelerometer—The all solid state Donner integrating accelerometer is used to both close a set of contacts at predetermined velocities and provide analog outputs relative to acceleration and velocity. These outputs are used in turn to actuate various control dynamics in missiles and aircraft. Velocity contacts can be closed at any speed from a few feet per second to 50,000 feet per second, up to accuracies of 0.25 percent over extended operational periods.

Key specifications: temperature range, 30° F to 150° F; vibration, will withstand ±15 g through 2000 cps; acceleration ranges, from 1 g to 100 g; shock, will withstand short shock pulses of 75 g and long pulses of 50 g; weight, 2 pounds.

Model 4403 Acceleration Switch—Donner acceleration switches are used to accurately determine the point of thrust termination in missile and satellite vehicles. Because of their high natural frequency, they offer excellent dynamic response.

Key specifications: ranges, 0.05 g to 100 g; unregulated power, 28 v dc ±10%; temperature range, 30° F to 150° F; output, relay closure; weight, approximately 12 ounces.

Model 4405 Jerkmeter—Unique Donner jerkmeters operate as subminiature servo-systems of the force-balance type responsive to jerk along the sensitive axis of the linear unit and about the sensitive axis of the angular unit. Basically, each system consists of a transistorized accelerometer with an integrator inserted into the servo-loop to generate a jerk signal. Applications include monitoring rate of change of g's in jet aircraft and using the signal to predict impending disaster, providing a velocity damping term, inertial indicator of first motion, and any other use where constant acceleration is required.

Key specifications: ranges, acceleration ±1 g full range to ±30 g full range; jerk, ±0.5 g/sec full range to ±20 g/sec full range; output full scale, acceleration and jerk, 7.5 v dc; weight, 7.5 ounces.

Model 7005 Airborne Analog Computer—Technically known as a "maximum altitude sensor," this all solid state system is a fixed purpose analog computer housed in a magnesium case only 5 inches long. It is used to actuate rescue devices in the capsule developed for the project Mercury.

Under abort conditions, the computer provides output information which fires the explosive bolts holding the escape tower onto the top of the capsule and energizes the system which causes the escape tower jettison rocket to fire.

OTHER DONNER SYSTEMS—

Donner Scientific specializes in the manufacture of accurate fixed and general purpose analog and digital systems designed to analyze, measure, and control inputs interlocking time, acceleration, jerk, velocity, and other dynamic inputs. Typical systems include accelerometer timer switches, airborne signal conditioner and event markers, escape and re-entry sub-systems, linear acceleration summing and storage devices, and peak reading vibration storage devices.

For more information, contact your nearby Donner engineering-sales representative or write Department 123.

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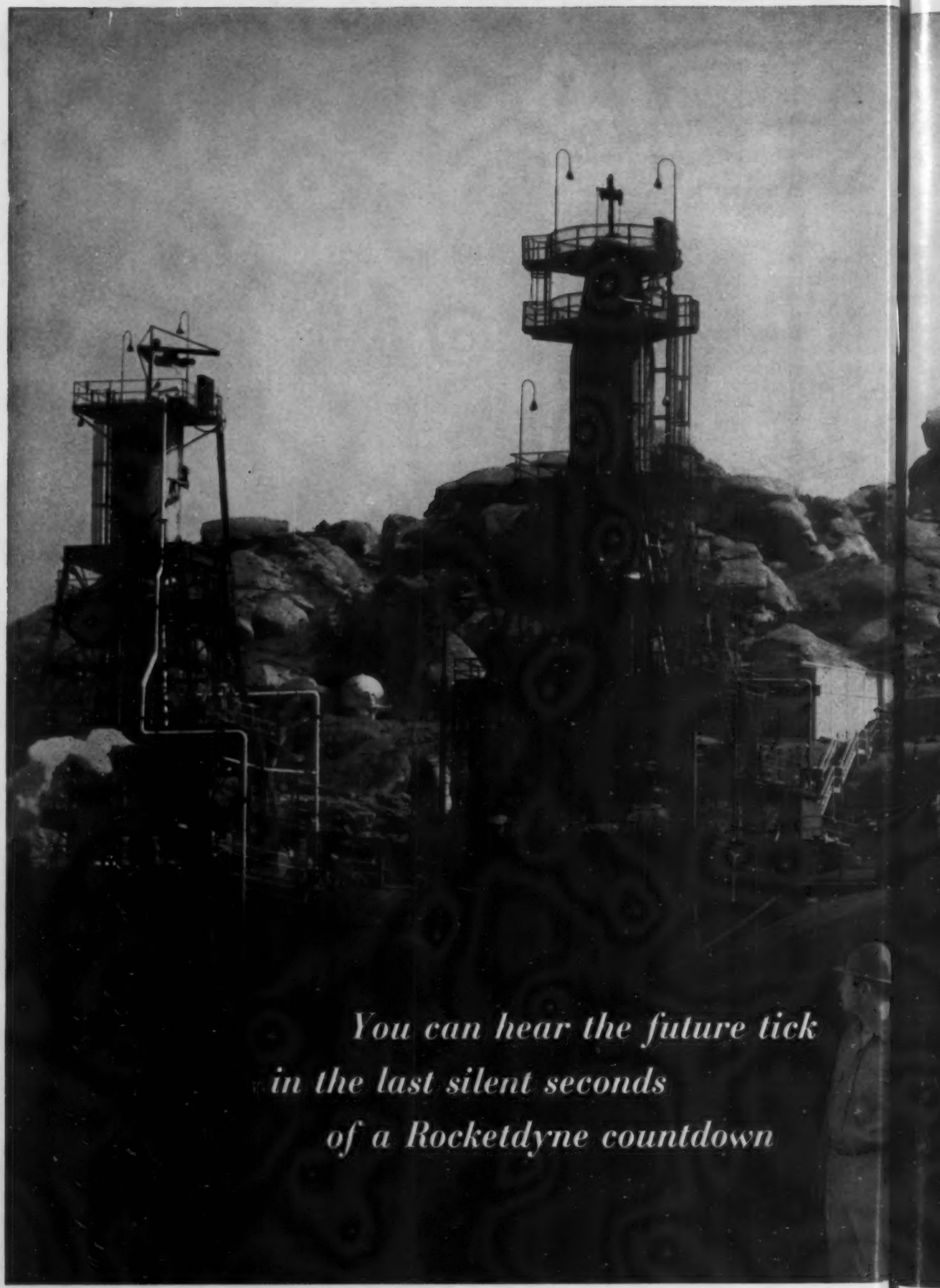
You can hear the future tick
in the last silent seconds
of a Rocketdyne countdown

FOUR...THREE...TWO...ONE... a moment of silence. Then a giant speaks—and a bolt of man-made lightning flashes.

Nearly every hour of every day, Rocketdyne technicians near that dramatic moment as they test and tune the space engines of today.

The best-equipped test facilities for high thrust rocket engines in the nation are at their command. Rocketdyne's finely instrumented test structures are located in California's Santa Susana Mountains; Neosho, Missouri, and McGregor, Texas.

Rocketdyne engines have powered most of the military and scientific projects conducted by the Air Force, Army, and NASA. Now huge boosters of one and a half million pounds of thrust are emerging from the technical heritage of Atlas, Thor, Jupiter, and Redstone.

And even while today's countdowns go on, plans for tomorrow's assault on space are being made. At Rocketdyne, engineers and scientists are investigating such advanced forms of propulsion as ion engines, nuclear engines, plasma jets, and magnetohydrodynamic engines. Meanwhile other groups are at work on high-energy liquid and solid propellants, and dramatic new devices for both liquid and solid propulsion systems.

Rocketdyne, a 12-year pioneer in rocket technology, was first with power for America's long-range ballistic missiles—first with power for Outer Space.

MEGABOOM—a giant solid propellant rocket motor produced at Rocketdyne's McGregor, Texas, solid fuel facility—delivers 100,000 pounds of thrust, boosts test sled to 1,200 mph.

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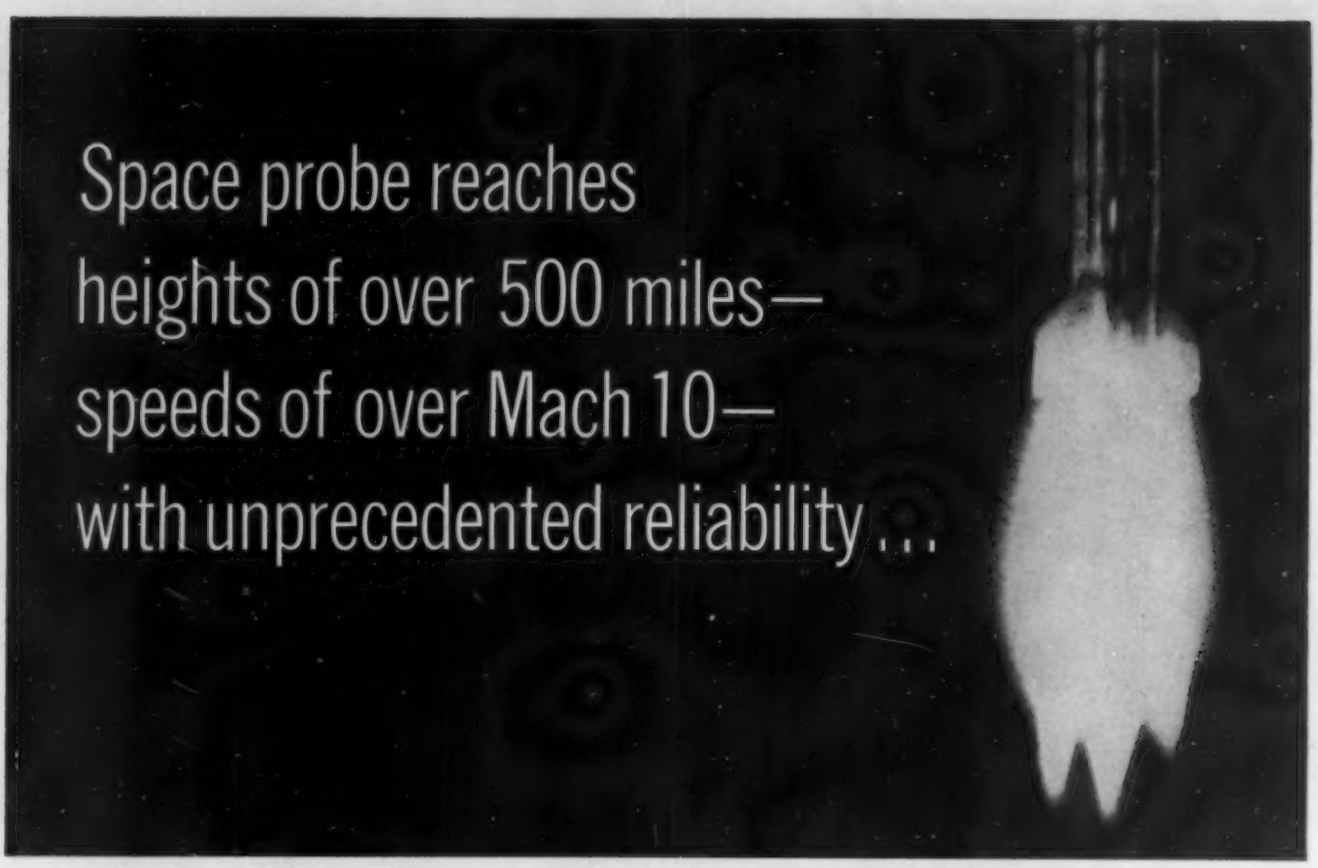

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At the Woomera rocket range in Australia, the Gamma has sent Black Knight over 500 miles into space at speeds in excess of Mach 10 with unprecedented reliability. For, to date, every Black Knight vehicle has been launched successfully.

Since Bristol Siddeley's rocket division began work in 1946, it has developed a wide range of components. *By combining these components in single or multi-chamber layouts, thrust requirements from 500 lb up to 100,000 lb can be met.*

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The Bristol Siddeley Orpheus powers the Fiat G 91, NATO'S light fighter.

The Bristol Siddeley Proteus powers the Britannia airliner.

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Step-up Urged in Ocean Study

Oceanography must be increased by a factor of four over the next 10 years—both in participants and in the present $36-million level of funding.

This statement came last week in a report on "Ocean Sciences and National Security," released by the House Committee on Science and Astronautics.

The committee pointed out the Soviet Union has accelerated its ocean research efforts in what may be a deliberate attempt to overtake and surpass oceanography in the United States.

In its recommendations, the committee stressed the threat manifested by the Soviet fleet of more than 500 submarines and said it is essential that we develop the capability in ASW for complete surveillance of the oceans to minimize the possibility of a surprise submarine attack.

It said the present level of scientific oceanic research and inventory of ships and shore facilities are evidence the field "has been badly neglected."

Examination of the Navy and National Science Foundation oceanic programs, the committee said, reveals that until Fiscal 1960, they appeared lacking in emphasis, vigor and adequacy of funding.

• **One manager**—The committee said the Navy, until recently, has not pursued a broad program in oceanography, despite its relevance to the Navy's ASW mission. The committee said this has been true even though the Navy is now the largest single supporter of oceanic research.

To remove the disparity between the current level of effort and the needs for national security, the committee said it is necessary that the Federal Government organize, manage, and coordinate the necessary program. It said the responsibility should be:

• Development of a national program in oceanic research and identification of goals.

• Budgeting of funds for a balanced program embracing all elements of oceanic research both for peaceful and military applications.

• Implementation of the national program by both in-house and contract research.

• Deliberate fostering of education and training in oceanography.

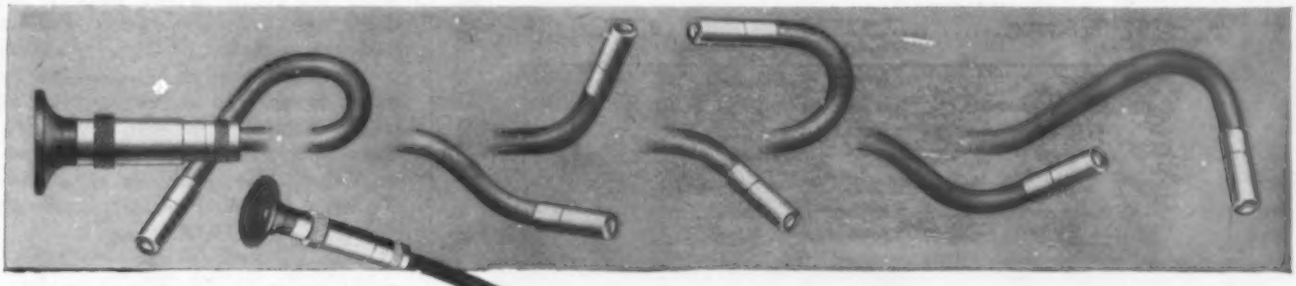
The report, authored by Dr. Edward Wenk, Jr., senior specialist in science and technology, Library of Congress, contained these other highlights:

• Marine subjects are being investigated at nearly 100 establishments which are subordinate to some 16 USSR ministeries and agencies. Leading oceanographic research institutions in the USSR are the Institute of Oceanology of the Academy of Sciences, the State Oceanographic Institute of the Main Administration of the Hydrometeorological Service, the Arctic and Antarctic Scientific Research Institute of the Main Administration of the Northern Sea Route and the All-Union Scientific Research Institute of Fish Economy and Oceanography.

• The number of professional oceanographers in the USSR is estimated as high as 800 to 900.

• The USSR's oceanic research fleet numbers between 50 and 75 non-military vessels with lengths greater than 50 ft. Included is the Severyanks, first submarine in the world to be used solely for oceanographic research.

The U.S., on the other hand, operates about 52 ships with an average age of 18 years, has about 500 to 600 professional oceanographers; and roughly 70 separate organizations engaged in oceanic research. Only 16, however, are large facilities.



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BY STANLEY M. INGERSOLL, *Capabilities Engineer*

Report No. 8
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Our new WR 2000 test set automatically tests "black box" modules having electrical inputs and outputs. It is presently being used to test modules of several different computer systems. Input command functions to the modules are obtained from a 5-place ratio transformer and are automatically programmed through a unique programming patchboard, which provides the WR 2000 with the versatility required to test a wide range of airborne analog computer systems. Output transfer functions of the modules are automatically read out through a 4-place ratiometer. Up to 10 input command functions and up to 10 output transfer functions for each input command are possible for each module. This SM/I test set can be operated by relatively inexperienced personnel, and its overall accuracy of measurement ranges from 0.01 to 0.25% of full scale, depending on type of test performed.

Physical Characteristics

Size	48" L x 25" W x 29" H — Table Area
Weight	200 lbs.
Power Requirements:	
115V 60 cps	300 watts max.
115V 400 cps	150 watts max.
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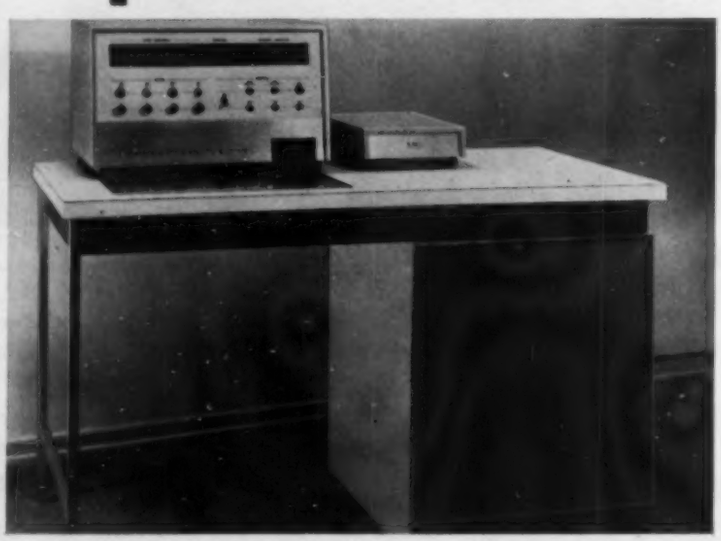

For more information and complete operating specifications, write or wire SM/I today. Address your inquiry to Stanley M. Ingersoll, Capabilities Engineer.

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SPACE MEDICINE

(Continued from p. 79)

hazard posed by prolonged exposure to weightlessness received a partial answer in the seven-day "bathtub" water-immersion experiment of Dr. Duane Graveline at the Aerospace Medical Center this past January. Will prolonged weightlessness requiring no muscular effort to maintain body position against the pull of gravity result in serious muscle debilitation and weakness?

Spending only one hour in each 24-hour period out of the bathtub to permit skin care and replacement of electrodes, the subject noted, "each time I got out I was weaker and more eager to get back in." A startling observation was the fact that he averaged only about an hour's sleep in each 24-hour period.

Monitoring his brain waves (EEG) proved that most of this was light sleep, with very infrequent 10- to 20-second periods of deep sleep. A marked decrement in skilled performance occurred, easily noted after comparing the pre- and post-experiment tests. This experiment points up one of the most serious and challenging problems of extended manned space flight.

The specific advances reportable through this past year appear to be small compared to the progress that needs to be made. However, the year has been a period of organization and consolidation that should blossom into many worthwhile achievements in the coming 12 to 18 months.

The opinions expressed are those of the authors and do not necessarily represent official USAF policy.

Rocket Power/Talco Pushes Studies of Oxidizing Salts

Advanced studies in improvement of solid rocket propellants are being carried out at the research laboratories of Rocket Power/Talco, Pasadena, Calif. Efforts are aimed at incorporating desirable properties of propellant oxidizing salts, such as perchlorates and nitrates, into propellant binders.

Accomplishment of the objective would result in a substantially homogeneous compound having excellent physical properties and high specific impulse.

Rocket Power/Talco scientists point out that the best present solid propellants consist of a minor proportion of binder and light metals with a preponderance of oxidizing salts, suffering in performance because of the need for separate components of binder and granular ingredients.

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Daystrom Gets Award For Added Work on Julie

Bureau of Naval Weapons has awarded Daystrom, Inc. a contract of about $2 million for continuing classified research and development work on the *Julie* system, an important part of Navy's anti-submarine warfare program.

Daystrom's Electric Division pioneered the *Julie* system for the Navy, beginning in 1953. The system makes use of the explosive echo ranging technique for the detection and location of submarines. Accurate timing between creation of the sound and receipt of its echo permits calculation of the distance between the submarine and the source of the sound.

In working on the system, the division developed a unique three-part setup. Its new laboratory building at Poughkeepsie, N.Y., includes a 12-by-8 ft. indoor acoustical water tank and other facilities to simulate the ocean environment.

To handle tests too large for the laboratory and yet under controlled conditions, *Julie* utilizes an artificial lake 1800 ft. long, 900 ft. wide and 135 ft. deep. Originally an abandoned stone quarry, it is the largest underwater test range in the country maintained by private industry.

To do original work in oceanography and to test ideas and equipment in the sea itself, the division keeps an 86 foot research vessel, the State Star, especially equipped and instrumented. The vessel works off the East Coast and in the Caribbean, often in conjunction with Naval ships and aircraft.

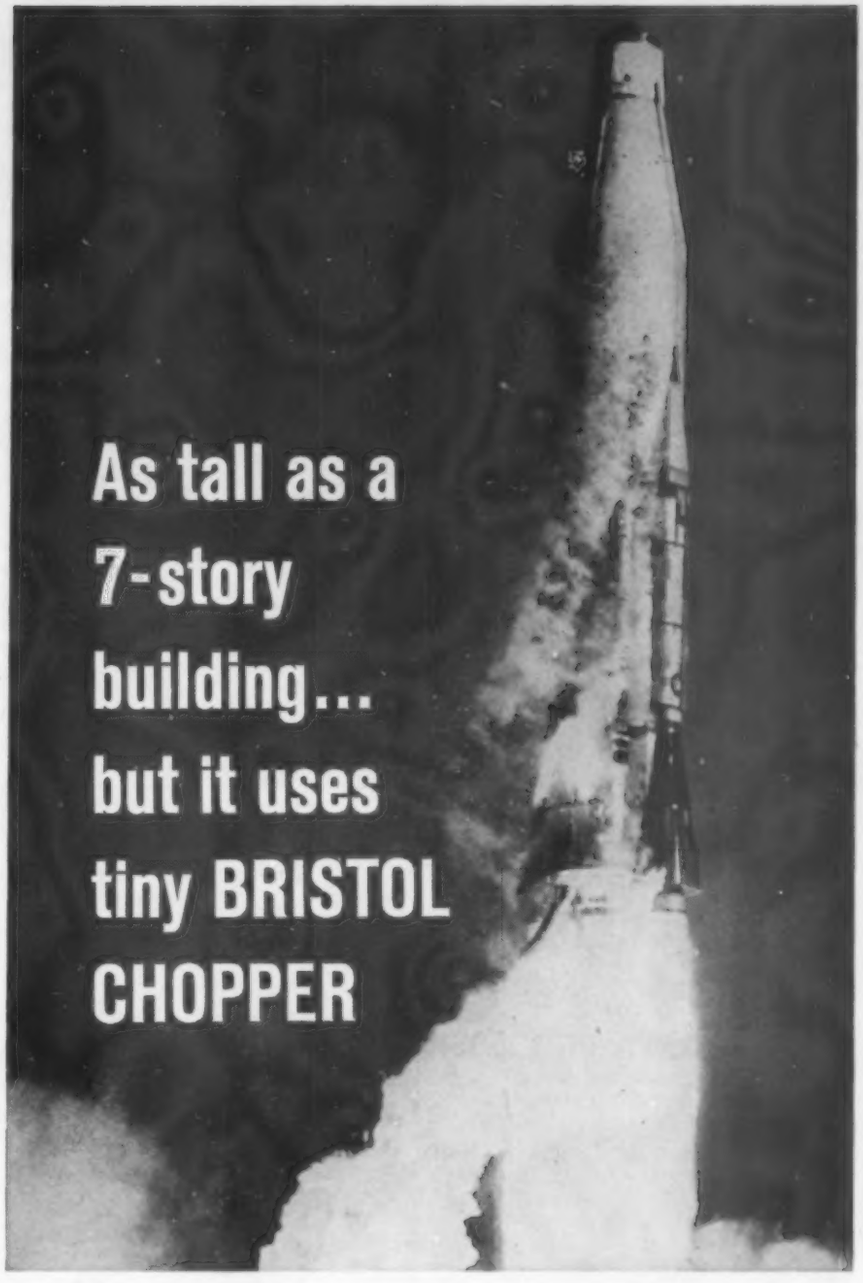
Martin to Develop Master Air Force Checkout Plan

A 15-year master plan of checkout systems for manned and unmanned weapons will be developed for the Air Force under a contract just awarded to Martin-Baltimore.

The study will set design standards and define checkout systems requirements up to 1975. It is also aimed at establishing methods of standardizing and integrating systems hardware to increase efficiency and save money.

Competition for the unfunded contract was unusually heavy: some 42 companies submitted bids. Martin estimates the work will cost them about $100,000 and require about seven months to complete.

Checkout equipment of 17 different weapons systems will be evaluated in the study. These include eight produced by Martin: SM-68 *Titan, Pershing,* TM-76 *Mace* and TM-61 *Mata-*



More than 40,000 parts, each of which must meet the most stringent reliability standards, make up the U. S. *Atlas* intercontinental ballistic missile, built by prime contractor Convair (Astronautics) Division, General Dynamics Corporation.

Among these parts is the Bristol Syncroverter* chopper . . . adding to its record of service in U. S. guided missile systems of almost every type since their very beginnings.

Billions of operations. To insure the reliability so necessary in aircraft and missile operations, Bristol Syncroverter choppers are constantly under test at Bristol, with and without contact load. One example: We've had five 400-cycle choppers operating with 12v, 1ma. resistive contact load, for more than 26,000 hours (2.96 years) *continuously* without failure—over 37-billion operations!

Many variations of Bristol Syncroverter choppers and high-speed relays are available—including external-coil, low-noise choppers. Write for full data. The Bristol Company, Aircraft Equipment Division, 173 Bristol Road, Waterbury 20, Conn.

actual size

*T.M. Reg. U. S. Pat. Off.

BRISTOL FINE PRECISION INSTRUMENTS FOR OVER SEVENTY YEARS

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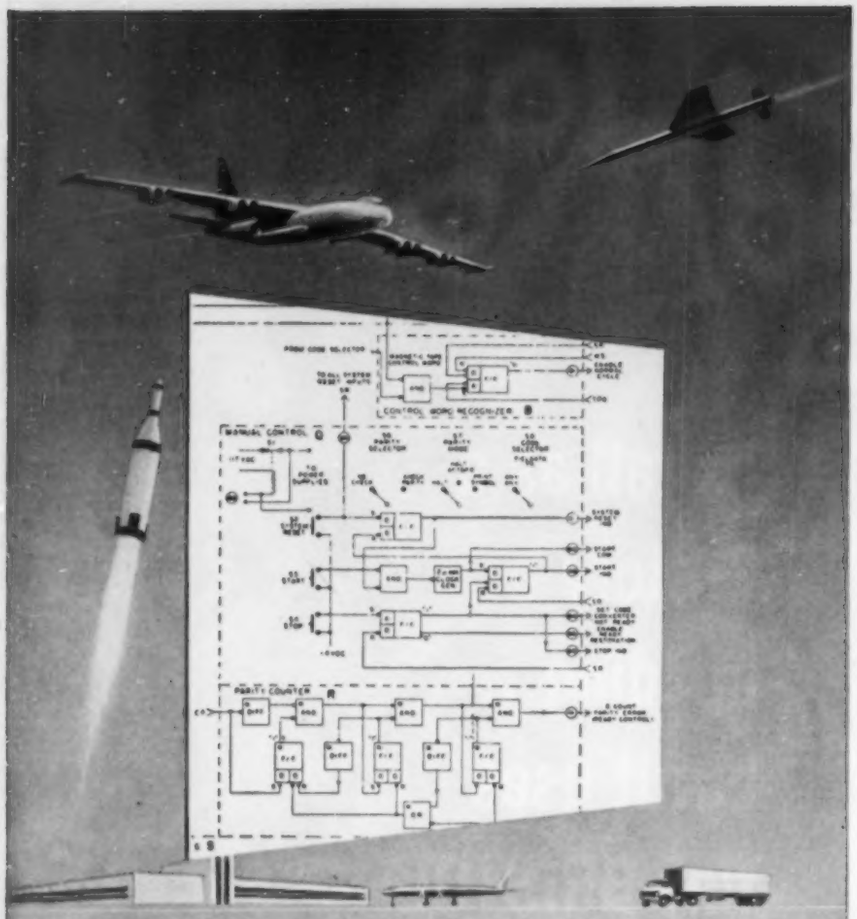

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• • • in tracking, timing, guidance and test systems is a familiar problem to Anelex® Systems Division engineers.

For almost ten years, they have worked together in the development of logical solutions to special military problems of air, land and sea operations, including equipment for MIL Spec environments. During this time, they have also developed unusual systems for industrial and commercial applications.

Finished equipment required for these systems is produced by the Anelex manufacturing facility under direct supervision of the engineering group. This division is staffed by technicians and skilled craftsmen who have specialized in the production of sophisticated data processing equipment.

We will be glad to tell you frankly and promptly whether your particular requirement is within the capabilities of our Systems Division.

for further information, write or telephone

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dor, Bullpup, 199-B ALBM (ex-*Bold Orion*), *Dyna-Soar*, and the RB-57D SAC reconnaissance bomber.

Other checkout systems included: SM-80 *Minuteman*, GAM-77 *Hound Dog*, IM-99 *Bomarc*, *Nike-Zeus*, GAR *Falcon*, GAM-87 *Skybolt*, B-58 Hustler, *Midas* early-warning satellite, and the *Samos* reconnaissance satellite.

IBM Demonstrates Its Mercury Tracking Network

A real-time teleprocessing system to serve as the connecting link between data input from widely scattered centers and central data processing was demonstrated in Washington recently for NASA and members of Congress.

Developed by International Business Machines Corp., the IBM 7281 Data Communications Channel will be installed soon at the Goddard Space Flight Center, Greenbelt, Md. Its 32 channels will tie the center's two IBM 7090's, also to be installed, to a world-wide network of tracking stations.

Transmitted information from any location in the network will be received by the 7281 which changes the impulses into a digital output. This can be stored and/or fed immediately into a computer for processing. Total elapsed time for teleprocessing, said IBM's Federal Systems Division, is measured in milliseconds.

Principally designed for Project *Mercury*, the tracking network inputs will be from radar, telemetry, and other related sources.

With the high-speed computers and the 7281, more reliable and precise control of the *Mercury* capsule is now possible. Real-time control obviates data delay in both directions—that is, to or from the capsule or the observing stations.

The equipment was demonstrated at the dedication of an impressive black-light display of U.S. space programs. Titled "Threshold of Space" the IBM exhibit dramatically shows what has been accomplished.

Joint Contract to Develop Mobile Nuclear Powerplant

A highly compact 2-to-3-megawatt nuclear powerplant for military use in isolated areas will be developed jointly by Allison Div. of General Motors and Nuclear Development Corp. of America.

The contract, awarded by the Atomic Energy Commission, grew out of a Department of Defense request for such a mobile system. The Army's Corps of Engineers particularly needs a high-output powerplant which can operate for long periods of time with minimal service requirements.

Pioneer V

(Continued from page 85)

ment of the interaction of solar wind and the earth's magnetic field, the first measurement of the size of the solar system by means of a space probe and a discovery that the so-called Forbush decrease in cosmic-ray intensity at the beginning of a solar flare is not confined to the region surrounding the earth.

Pioneer V exceeded the long-distance communication record by more than 55 times. The old record was held by *Pioneer IV*, the 13.4-lb. U.S. planetoid fired past the moon March 3, 1959, which was tracked out to a distance of 407,000 miles. Silverstein said the longest distance of communication claimed by the Soviets was 396,000 for *Lunik I*, their 3245-lb. vehicle fired past the moon Jan. 2, 1959.

Since last March, *Pioneer IV* has traveled 760 million miles in its orbit.

• **Failure analyzed**—Most of the communication from *Pioneer V* came from its five-watt transmitter. The probe also carried a 150-watt transmitter, which was left idle during the first four weeks of its journey. The larger transmitter responded promptly when commanded on for the first time on May 8. However, its use was limited because of the apparent deterioration of the spacecraft's 28 flashlight-sized batteries. The 5-watt transmitter is powered by batteries recharged by solar cells in four paddles stretching out from the body of the satellite.

NASA said any one or all of the three reasons might account for the failure of communication. They are:

• The spacecraft may be out of earth range of the 5-watt transmitter.

• Battery failure or leakage may have been induced by the extreme vacuum of interplanetary space.

• Some key component or system may have failed.

NASA and Space Technology Laboratories, which built the *Pioneer V* payload, are making a complete analysis of the performance, including the 138.9 hours of data transmission.

First Missile Destroyer For Royal Navy Launched

LONDON—The Royal Navy has launched its first guided missile ship, the destroyer Devonshire. It should be ready for fleet service in early 1962.

Missile armament will include a *Seaslug* mounted on the quarter deck and two *Seacats* abaft the after funnel. The vessel will also have the latest ASW detection equipment.

Three sister ships—Hampshire, Kent and London—will be in service by 1963.

Photo courtesy Radio Corporation of America

aerospace

Components for RVX and TIROS Projects by LAVELLE

Major successes in the nation's accelerated space vehicle and missile programs include precision sheet metal components made by Lavelle. Among these is the fabrication by Lavelle of the structure of the new U. S. earth-circling TIROS weather observation satellite produced for the National Aeronautics and Space Administration by the Astro-Electronics Products Division, RCA. An artist's view of TIROS in orbit is shown above.

Photo courtesy World Wide Photos, Inc.

Pictured also is the recovery of the first successful RVX series re-entry vehicle after ICBM range flight. The aluminum alloy nose cone structure for this test was fabricated by Lavelle under sub-contract from the General Electric Company's Missile and Space Vehicle Department.

Some of the reasons why Lavelle has been selected to be a part of such dramatic projects are illustrated in a new brochure. Write for your copy.

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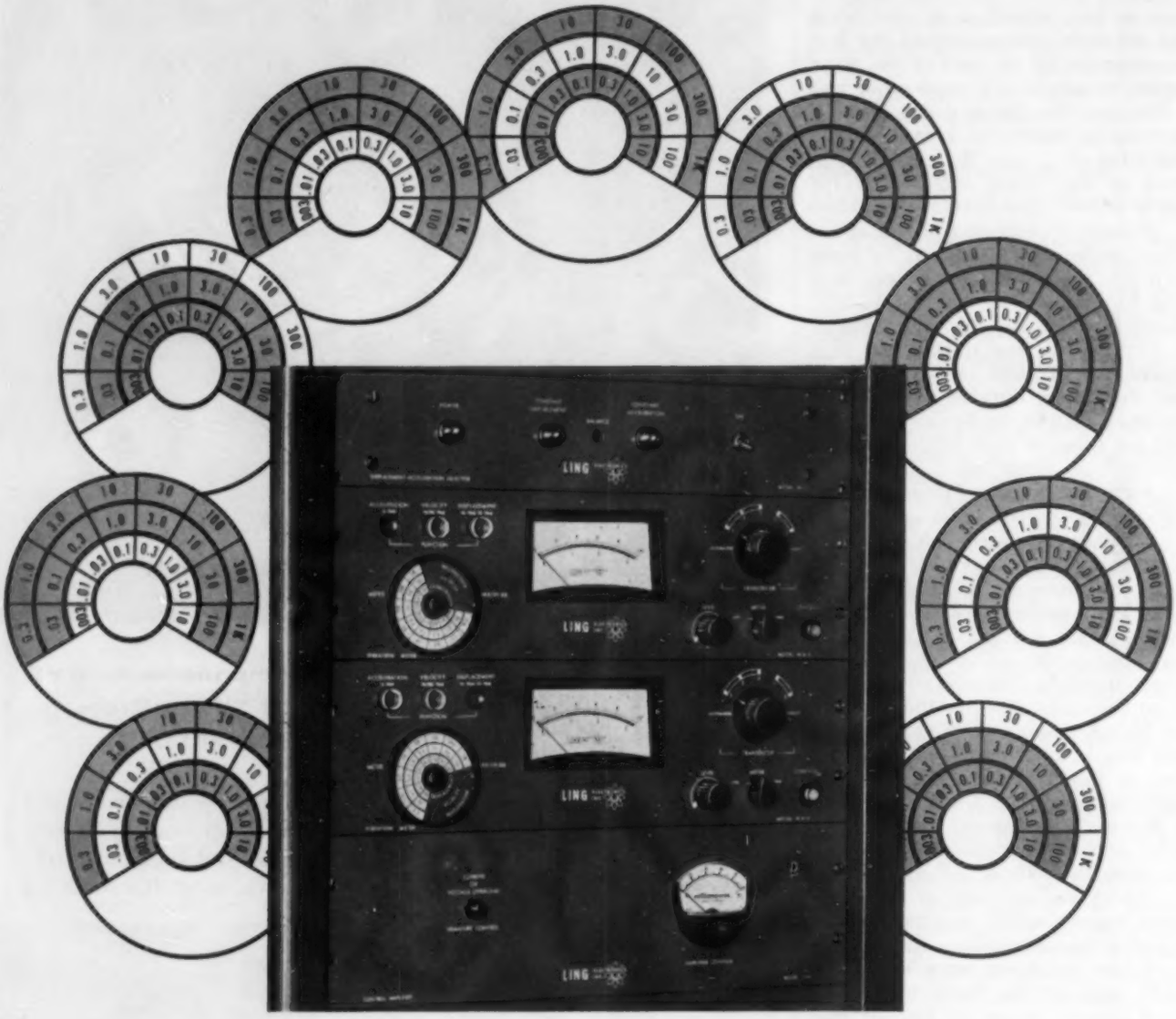

AUTOMATION IN VIBRATION–Vibration variations of 1000 to 1 automatically controlled by NEW LING S-14 SERVO

Ling introduces another advance in vibration testing—a new electronics servo system that offers a dynamic range of 60 db, plus remarkable accuracy and ease of control. This new variable response S-14 Servo System performs automatically, while frequency cycling with a sine-wave signal source. It simultaneously monitors any two values of acceleration, velocity or displacement, then automatically selects the larger as the controlling signal, and maintains it constant. Automatic thumpless transfer between the control functions takes place—you simply set the desired limits on the corresponding vibration meter. Reaction time is inversely proportional to frequency, and as a result, controlled levels of plus or minus 3% are attainable over a wide dynamic range. Like other Ling designs, the S-14 is flexible—the basic system can be expanded to handle 4 separate signals, or to permit automatic control from 3 or 4 control signals. For details, write Dept. MR-4 at our Anaheim address.

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LING ELECTRONICS

The flexibility of the S-14 Servo System at the left, is just one more example of the way Ling design anticipates your needs of the future. Since the complete control package is made up of separate components, the system not only meets your present demands, but can readily be expanded. The basic two-level system includes 2 vibration meters, 1 control amplifier, 1 control selector,

By simply adding the appropriate number of meters and selectors, the system can be expanded to meter 3 or 4 separate signals with automatic transfer between control functions.

Transfer between control functions is handled by an electronic switch which automatically selects the correct crossover point. You merely set the desired limits on the corresponding vibration meter, shown close-up in the photo below. No thumps or other low frequency transients mar this smooth transfer.

This kind of flexibility, precision control and ease of operation begins with thoughtful consideration of basic operating requirements. And whatever your needs in high-power electronics—for vibration testing, acoustics or sonar—you'll find you can rely on Ling Electronics for the thoughtful design that leads to practical advances.

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HIGH-POWER ELECTRONICS FOR
VIBRATION TESTING • ACOUSTICS • SONAR

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'cocktail party effect . . .'

New Sound Technique For Voice from Space

SANTA BARBARA, CALIF.—Astrometrics, Inc., has developed an entirely new sound reproducing system for voice transmission from space based on a principle observable at any cocktail party.

The system, called the "articulator," is designed to increase the intelligibility of an astronaut's voice under conditions of a high ambient noise level at the listening end, the transmitting end or in the transmission link itself.

It makes use of the fact that human ears are directional devices relying on both amplitude and arrival time differences for information. Sound emanating from in front and to the right of a listener will arrive at his right ear first, thus allowing the brain to decide where the source is. If two or more sounds are being generated at different locations, the listener has the ability to "tune up" the sound he wants and "tune down" the other.

This is what Astrometrics calls the "cocktail party" effect and it forms the basis for the Articulator, designed to make transmission from an astronaut more intelligible.

"This capability of the listener to tune in on one of the conversations and tune down all other conversations and noises in the room is dependent on his ability to locate the source of the sound he is after," company president W. M. Turner notes. "There's both a physiological and a mental mechanism at work here."

Yet a tape recording taken in the same room will produce substantially unintelligible and confused sounds with only a few highlights coming through, Turner points out. This is attributed in large part to the fact that the tape-recorded sound emanates, in effect, from only one source.

• **Three frequencies used**—By feeding all desired and undesired signals from a single channel line into a phase shifter which has the characteristic of presenting two outputs with a constant phase difference relationship at all frequencies, (i.e., all frequencies from 20 to 20,000 cps are 90° apart at the two output terminals), a precise but different time delay from one output to the other results for every individual frequency component in the sound.

Ninety degrees represents 2.5 milliseconds difference at 100 cps, 250 microseconds at 1000 cps, and 25 microseconds at 10,000 cps. If these three frequencies are transmitted by two widely spaced speakers and the 90° phase relationship maintained, the three frequencies appear to the listener to be coming from three different locations between the two speakers.

Each voice has an attack transient containing a band of identifying frequencies. These become locating frequencies in a system of this type. If several voices, hum, and static all are

Model 100 Articulator Specifications

Input Impedance:	greater than 47 K Ohms
Input Voltage: (required for rated power output)	1 Volt RMS
Input Signal Range:	0.1 to 5 Volts RMS
Output Power:	10 Watts (each channel)
Output Impedance:	4 Ohms (each channel)
Intermodulation Distortion: Harmonic Distortion: Frequency Response:	not applicable (function of speaker and ambient parameters)
Improvement:	The average intelligence signal to noise ratio improvement is 3 db.
Power Required:	117 VAC 60 cps single phase at 1.25 amperes (nominal)
Physical Dimensions	
Amplifier and Control Unit:	5¼" H x 19" W x 13½" D
Speaker Units:	5¼" H x 19" W x 7½" D

Whether shooting for the moon or pinpointing an ICBM in the Atlantic, success or failure already has been determined before the button is pushed. Hit or miss depends upon the *reliability* of men, component parts, and support equipment.

Reliability of Hokanson missile support air conditioning has been proven in support of the Snark, Polaris, Thor, Titan, Minuteman, and Quail programs. Hokanson also has demonstrated its ingenuity by solving new and unusual air conditioning design and performance requirements.

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being transmitted over one line, then, with the Articulator, the hum will seem to be coming from one point, one voice from another point and so on.

"The listener will subconsciously locate the desired sound and tune down all others, something that would be impossible if they were all following each other out of the same box," Turner says.

It is this which the company says greatly enhances the ability of the listener to extract the intelligence from a single channel sound transmission system. He can, in effect, "tune in" mentally on the astronaut's voice.

"Prior to the space age, important information in missile programs was derived from the radar, telemetry, and on board recording devices," says company president Turner. "Voice communications played a secondary role, only important at certain points in the countdown and during an occasional emergency transmission from a chase plane pilot. However, with the advent of men in space, we have in addition to the aforementioned sources of intelligence, the astronaut himself. What he says will be of great importance, so that the human voice as a source of data will be of primary or paramount importance as opposed to unmanned missile programs."

Turner points out that recovery of the human voice under conditions of space travel is a field on which very little effort has been expended.

Development of the Articulator is aimed at improving the intelligibility of man's voice under space conditions and is an effort to increase the useful range of transmission without further encumbering the vehicle or the astronaut himself.

• **Used with telemetry**—The Articulator is added to the ground communication system between the final electrical voice output and the human receiver. The communications system up to the human receiver is immaterial to the Articulator. It can be AM, FM, single sideband, double sideband, constant level speech, narrow band FM, phase modulation or any other. It can be landline communications, it can be clipped, or it can be digitized and then reconstituted in an analog form.

Application of the Articulator is not limited to space programs but can be used in any communications system where intelligibility is important. It could be employed, for example, in playback of telemetry data where information for the annotation of records is derived from voice signals on the tape along with the telemeter information.

There are three separate units making up the Model 100 Articulator. The

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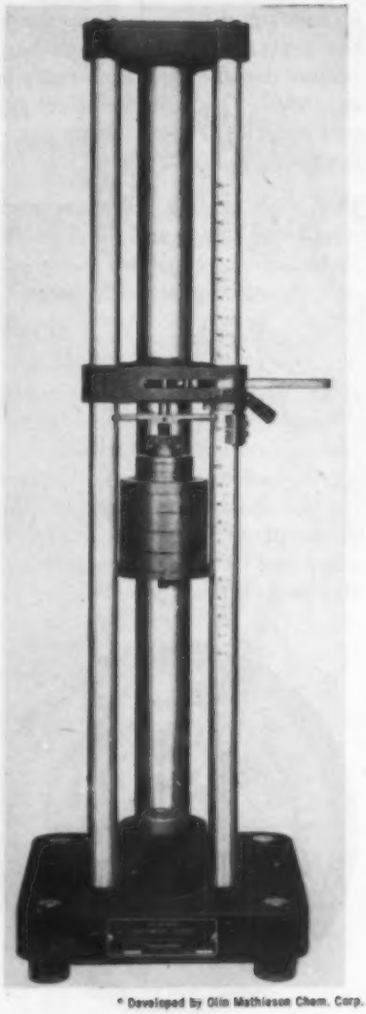

* Developed by Olin Mathieson Chem. Corp.

VERSATILE: Particularly suitable for impact sensitivity testing all classes of materials, both solid and liquid, including slurries and low-boiling liquids.

SAFE: Convenient laboratory tool for determining the safety of handling new or unknown materials.

RAPID: One half-hour or less for a complete determination (20-30 tests).

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NEW HIGH PERFORMANCE

Size 8 Motor Generator

This new Size 8 high performance servo motor-generator features high signal output and extremely low null voltage. The signal-to-noise ratio of 100:1 and linearity of 0.2% make the application of this motor generator to light-weight integrator packages most desirable. Stainless steel construction and thermal stability of this component assure its reliability and long life in the most severe environments.

ELECTRICAL CHARACTERISTICS

Motor Section	Generator Section		
	Phase 1	Phase 2	Excitation
Voltage (volts)	26	40	26
Frequency (cps)	400	400	400
Current (ma)	110	77	72
Power Input (watts)	2.3	2.3	1.3

GENERATOR SECTION OUTPUT

Volts at RPM (mv)	10
Volts at 1000 RPM (volts)	1.1
Output Impedance (ohms)	21 + j2500
Rated Load (ohms)	100,000

MECHANICAL CHARACTERISTICS

No Load Speed (RPM)	6500
Stall Torque (In. Oz.)	0.25
Rotor Moment of Inertia ($gm\text{-}cm^2$)	1.2
Theoretical Acceleration (Rad/Sec^2)	14,400
Weight (Oz.)	3.9

Write for complete data.

BASIC BUILDING BLOCKS FROM KEARFOTT

QUADRATURE REJECTION CIRCUIT

Kearfott's quadrature rejection circuit is designed to operate from a pre-amplifier or gain controlled amplifier into a transistor servo amplifier. This small, light and rugged device rejects the component of the input wave which is 90° from the reference input. The component of the input sine wave which is in-phase with the reference will produce a square wave whose magnitude is proportional to load and magnitude of in-phase signal. Kearfott's high-performance rejection circuit is designed to operate in an ambient temperature range of −55°C to +115°C at unlimited altitudes.

TYPICAL CHARACTERISTICS
ƒD4816-01

Input Impedance — In phase signal component (ohms)/5000 $+R_L$ / Quadrature component (ohms)/5000 (min)
Signal Frequency (cps)/400
Max. Signal Input (volts RMS)/6
Bandwidth (cps)/6
Quadrature Rejection Ratio:
Rejection Ratio (min)/50:1/35:1/35:1
Signal Input/0.15 to 4/4 to 6/0.005 to 0.15
Meets environmental requirements of MIL-E-5272.

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BASIC BUILDING BLOCKS FROM KEARFOTT

TWO AXIS ACCELER-OMETERS

Highly precise and accurate, Kearfott two-axis accelerometers are pendulous devices which sense airframe acceleration forces acting on them in aircraft and missile guidance systems, navigational computers and wherever acceleration must be measured precisely and translated into electrical output signals.

The pendulum is anchored to a housing by means of a unique Hooke's joint type spring suspension. Whenever there is relative motion between pendulum and housing due to acceleration, an AC excited, air-core differential transformer type pickoff produces a voltage which is a servo error signal that is fed into an AC to DC amplifier. Feedback signal in form of a DC current transmitted to a restoring coil produces a force that exactly balances force of any accelerations acting on pendulous mass.

TYPICAL CHARACTERISTICS

Range of Measurement: ± 25g (can be adjusted upward within amplifier limits.)
Scale Factor (Output): 5.0000 MA/g of applied acceleration.
Operating Temperature: Performance is optimized within any 20°F range between +50°F and +160°F.
Linearity (Output): Within ± 0.005% of the applied acceleration.
Threshold: Less than 2×10^{-7}g.
Zero Stability: ± .00005g day to day; less than ± .00002g over any continuous time interval.
Vibration: Up to ± 5g peak from 20 to 2000 CPS.
Storage Temperature: −60°F to +170°F.
Scale Factor Variation: ± 0.01% randomness.

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Little Falls, New Jersey

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Other Divisions: GPL, Librascope, Link

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POLARIS FBM
PROJECT ARGUS

DISCOVERER SATELLITE

EXPANDING THE FRONTIERS OF SPACE TECHNOLOGY

ADVANCED PROJECTS AT LOCKHEED

POLARIS FBM—Now in its advanced development status, the Navy-Lockheed POLARIS Fleet Ballistic Missile is scheduled to be fully operational and aboard its specially designed submarines late this year. Full-scale test vehicles have been successfully flown on a regular schedule of firings for months with only two failures, a remarkable achievement in view of the totally different environmental problems involved in its underwater launch. With nearly three-quarters of the earth's surface being water, practically no target in the world is outside the POLARIS' range of over 1200 nautical miles. The Division is systems manager for the POLARIS under the direction of the Special Projects Office of the Navy.

SATELLITE PROGRAMS—The Air Force-Lockheed AGENA satellite is a versatile space vehicle capable of numerous assignments. In its present DISCOVERER program configuration, it is 19 feet long, 5 feet in diameter with an orbital weight of approximately 1700 pounds. Payload of several hundred pounds includes telemetry, instrumentation, guidance and attitude control systems, reentry vehicle and recovery capsule. The AGENA has accomplished several significant space "firsts." It was first to be placed on the difficult polar orbit; first to be placed on a precise, predicted, and nearly circular orbit; first to change its attitude on orbit, with a turn of 180 degrees and a downward tilt of 60 degrees; first to eject a capsule; and first to prove advanced space systems such as ground-space communications, instrumentation, attitude and guidance and life-sustaining devices. The AGENA can be modified for a variety of space missions such as navigation; geophysical investigations; lunar probes; long-range communications; and space probes.

In addition to the DISCOVERER program, the Division is developing advanced AGENA satellites for the MIDAS program (Missile Defense Alarm System) and the SAMOS strategic warning system. Lockheed is system manager and prime contractor for these projects under the direction of the Air Force Ballistic Missile Division (ARDC).

SPACE STATION—An orbiting research facility to serve as an advanced base for space exploration, has been proposed in practical detail by Lockheed's research and development staff. The station would carry a 10-man crew. Prefabricated compartments for the rim of the wheel, the spokes, and the three hubs would be launched separately by ballistic missiles and assembled in space by means of the specially-designed, Lockheed Astrotug.

X-17, KINGFISHER, X-7—The Air Force-Lockheed X-17 solid-propellant ballistic missile has pioneered many new techniques, and the valuable experience gained from this program facilitated development of other, inter-service projects, including the Navy POLARIS FBM. The Navy's Project Argus radiation explosion featured the X-17 as the vehicle. Developed for the Air Force, the Lockheed KINGFISHER is designed to simulate enemy attacks to test our nation's anti-bomber and anti-guided-missile defenses. The Air Force X-7 is a unique, recoverable ramjet-engine test vehicle designed to test new developments in advanced components for other missiles.

The successful completion of projects such as these requires a bold and imaginative approach to entirely new environments. Lockheed's programs reach far into the future. It is a rewarding future which scientists and engineers of outstanding talent and inquiring mind are invited to share. Write: Research and Development Staff, Dept. G-29A, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship or existing Department of Defense industrial security clearance required.

Lockheed / **MISSILES AND SPACE DIVISION**

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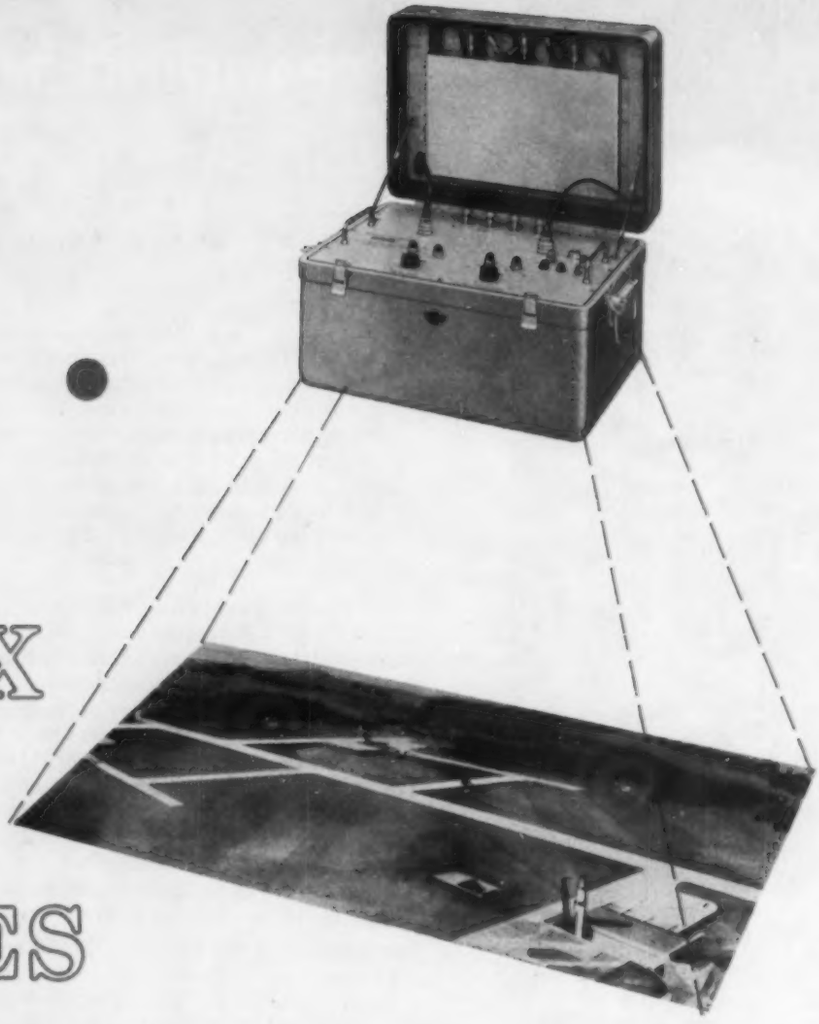
the new Giannini Portable Pressure Generator



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From 10 acres of launching area to a laboratory bench... in Ground Support, production or research ...now you can find a compact, portable Giannini Pressure Generator to do any of these things:

- Obtain precise static and pitot pressure readings from two related electromechanical pneumatic systems.

  Inspect, production-test and calibrate such systems. Test them on the flight line. Furnish arbitrary pressure outputs as a function of voltage inputs (manually or remotely selected) for simulated flight of missiles, aircraft and other vehicles.

- Generate absolute, differential or gage pressures and pressure ratios. Direct digital readout. Select from a variety of accuracies, resolutions, pressure ranges, ratios, rates.

Designed for maximum utility, Giannini's new pressure generators are easily transported. Rugged mechanically. Simple electronically. Give long, trouble-free life in lab or field.

Proof of performance: this useful new Ground Support unit is currently being used to test the Giannini Variable Inlet Control System on a new supersonic jet interceptor.

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Specifications, Giannini Portable Pressure Generator

OPERATING MEDIUM
Dry (instrument) air

OPERATING INPUTS REQ'D.
Air Pressure: 20 to 30 PSIG
Vacuum Source: 0 to 2.0 inches of mercury (absolute)

OUTPUT PRESSURE RANGES
Static Pressure (P_s): 2 to 70 inches of mercury (absolute)
Pitot Pressure (P_t): Automatically determined by P_s and P_s/P_t settings
P_s/P_t Ratio Range: 0.580 to 0.940
Other Static and Ratio ranges available.
Differential Pressure Range: 0 to 30 inches of mercury.

POWER REQUIREMENTS
110 volts, 400 CPS—275 watts

OVERALL DIMEN. (Approx.)
Height: 14.5 inches
Width: 24 inches
Depth: 16 inches

AMBIENT TEMPERATURE
Range: —54°C (—65°F) to +55°C (+130°F)
Weight: Approx. 80 pounds

GCC 0-3

Giannini Controls Corporation 1600 South Mountain, Duarte, California

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main chassis contains the controls, a 90° phase shifter, two separate audio servosound amplifiers and a DC power supply. The other two units are identical speaker enclosures with the exception of the location of barrier terminal strips on the rear section.

In use the two speaker enclosures are placed at the same height on the same plane with a center to center distance in the range of 6 to 20 ft. Cables 10 ft. in length are provided for connection of the speaker enclosures to the main chassis.

Astrometrics has determined, using series of random-number and other tests on listening groups under a variety of ambient listening conditions, that the average intelligence improvement under conditions of noise in the transmission link is 3 db. An improvement of this magnitude would, in the case of a moving aircraft, result in a range increase of 1.4 to 1.

The improvement in intelligibility under conditions of ambient room interference is said to be much more spectacular. Astrometrics explains the improvement this way:

Consider the case where a voice is emanating from a single speaker in a room with an interfering voice at a higher amplitude than the desired reproduced voice. If the amplitude peaks of the interfering voice are sufficiently high to override the desired voice, a listener can no longer keep his physical and mental machinery "tuned to" or "locked on" the desired voice and is thereby distracted by the interfering voice. In the case of the Articulator's two outputs with 90° phase difference, if the interfering voice peaks are coincident and override the peaks of the voice emanating from one speaker, it necessarily follows that they cannot interfere with all of the peaks coming from the other speaker—since the sounds from the other speaker arrive at a different time. All of the intelligence-containing components of the voice arrive at different times, so that even if the interfering voice were to be coincident with some frequencies, it cannot coincide with others because there is an arbitrary and varying difference in time delay between the two speakers.

• **Negative feedback**—If a rapid-speaking, interfering voice, such as a radio commercial, is turned on at a volume greatly exceeding that of a desired single channel signal reproduction, the desired signal is virtually unintelligible. The recovery ratio is approximately 10%. Addition of a second speaker, at no increase in volume, increases the intelligibility to 95 or 100%. Effectivity of the Articulator phase relationship is said to be even more pronounced with use of a stereophonic headset because the phase relationships are retained in their pure state and therefore are not deteriorated by room reflections.

It is coincidence that the intelligence or fidelity increasing mechanism of each of the two channels considered separately in the Articulator also is a phase function. The Articulator has a novel feedback circuit which treats the speaker itself as a transducer and reflects variations from a pure resistive load back into the amplifier in a negative feedback sense. The particular feedback arrangement employed results in essentially a "constant power" amplifier characteristic. The amplifier is neither constant voltage nor constant current, but constant power. The constant power relationship has been determined, through empirical study, to produce the highest auditory fidelity.

Harmonic distortion measurements made on speakers using this feedback versus pure voltage feedback in the conventional sense will yield a greater harmonic distortion reading. However, since the speaker is resistive only at two frequencies and is either capacitive or inductive at all other frequencies,

PROVEN RELIABILITY—
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over 260,000 logged hours— voltage-regulated, frequency-controlled, for missile, telemeter, ground-support, 135°C all-silicon units available now—

Interelectronics all-silicon thyratron-like gating elements and cubic-grain toroidal magnetic components convert DC to any desired number of AC or DC outputs from 1 to 10,000 watts.

Ultra-reliable in operation (over 260,000 logged hours), no moving parts, unharmed by shorting output or reversing input polarity. Wide input range (18 to 32 volts DC), high conversion efficiency (to 92%, including voltage regulation by Interelectronics patented reflex high-efficiency magnetic amplifier circuitry).

Light weight (to 6 watts/oz.), compact (to 8 watts/cu. in.), low ripple (to 0.01 mv. p-p), excellent voltage regulation (to 0.1%), precise frequency control (to 0.2% with Interelectronics extreme environment magnetostrictive standards or to 0.0001% with fork or piezoelectric standards).

Complies with MIL specs. for shock (100G 11 misc.), acceleration (100G 15 min.), vibration (100G 5 to 5,000 cps.), temperature (to 150 degrees C), RF noise (I-26600).

AC single and polyphase units supply sine waveform output (to 2% harmonics), will deliver up to ten times rated line current into a short circuit or actuate MIL type magnetic circuit breakers or fuses, will start gyros and motors with starting current surges up to ten times normal operating line current.

Now in use in major missiles, powering telemeter transmitters, radar beacons, electronic equipment. Single and polyphase units now power airborne and marine missile gyros, synchros, servos, magnetic amplifiers.

Interelectronics—first and most experienced in the solid-state power supply field produces its own all-silicon solid-state gating elements, all high flux density magnetic components, high temperature ultra-reliable film capacitors and components, has complete facilities and know how —has designed and delivered more working KVA than any other firm!

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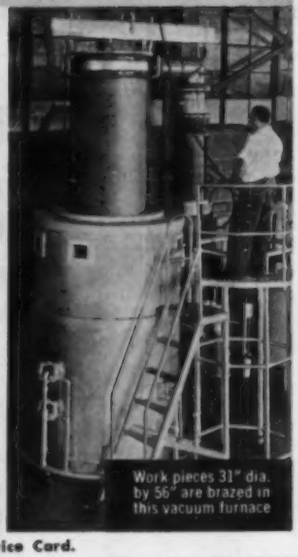
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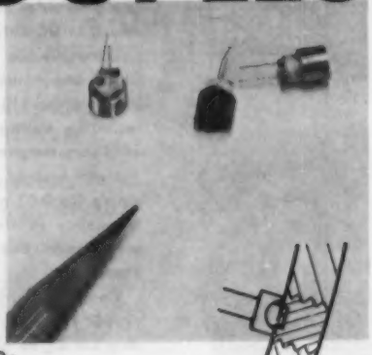

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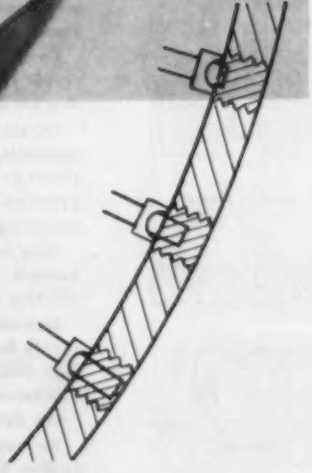

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there is a phase difference between the cone movement at all different frequencies from a given speaker.

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Astrometrics believes there is an important delineation which should be made between the mechanism of phase delay or constant phase shift as employed in the Articulator and the time delay mechanism used in the past by the military.

In the case of the time delay, which has been found to increase intelligibility in aircraft, the principle is this: if a sound generated at the right ear is interfered with, by some ambient noise peak, that same noise sound arrives at the left ear later in time and may, by coincidence, not be interfered with at all.

It is certain that the same peak that interfered with the sound in the right ear will not affect the left. However, in the case of the Articulator, since there is a varying time delay for all of the different frequency components of the desired signal, an interfering sound at the right ear cannot interfere with any of the components from the left ear. An additional interfering sound that might affect one component of the left ear can necessarily not interfere with all of the components since they are distributed in time.

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1892 RUDITZKY'S ROCKET-BOAT WHICH EXPLODED ON THE VOLGA EARLY IN 1893
1885 BRYCE-BETTANCOURT ASCENDS IN A ROCKET-POWERED BALLOON TO CLAIM THE ALTITUDE RECORD FOR THE ROYAL "BALOONATICS" CLUB.
1887 PRAISED HIGHLY BY HIS PHYSICS MASTER FOR HIS ADVANCED WORK IN FUELS, VLADIMIR POPOWSKI DISCOVERED MANY PITFALLS -- WHICH HELPED PAVE THE WAY FOR ROCKETRY, AS WE KNOW IT.
1902 ADOLF ZIMMER -- SOMETIMES CALLED THE ICARUS OF ROCKETRY IN AN EARLY MODEL, THE ZIMMER "ZOOMER"
AN EARLY ROCKET
LE CHANDEL ROMAN
A RARE SHOT OF ETIEN GASPAR DE BOURBONVILLE, NOTED DAREDEVIL, WHO WON THE PARIS TO MADRID RACE AGAINST 7 HORSES AND A MULE.
FINIS
TOP SECRETSKI
JOACHIM PULLIZPANZOF - 22. PROBABLY THE WORLD'S MOST FAMOUS MASTER SPY, USED THE ROCKET TO CONVEY MESSAGES TO BELGRAVIA, ACROSS THE MESOPOTAMIAN FRONTIER.
COURTESY OF THE FRENCH PICTORIAL "LES INVENTEURS CRACKPOTIQUE DE 1913"
-COLIN BAILEY.

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Fourth Annual

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1960

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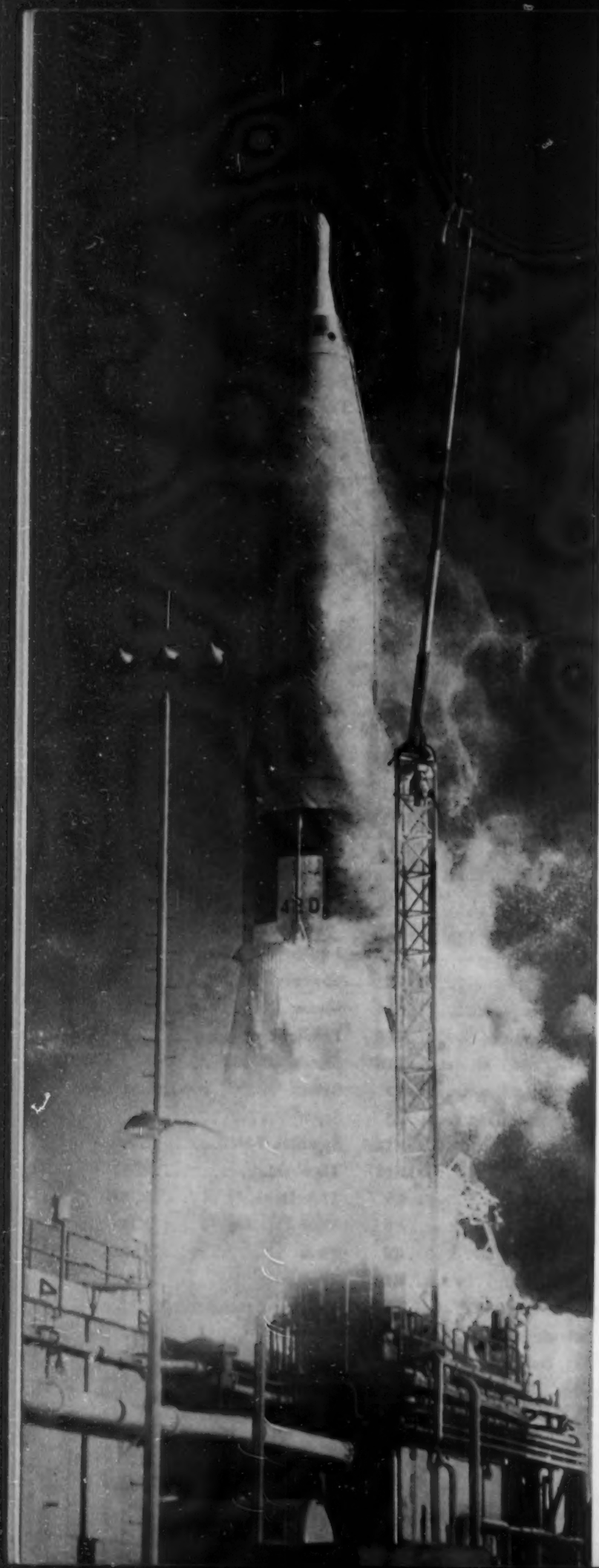


STRATEGIC

U.S. strategic missiles become a major factor in the Cold War for the first time in 1960.

Several Air Force Atlas ICBM's became operational at Vandenberg AFB, Calif., in the fall of last year. But they were only a token.

By the end of 1960, one or more squadrons of Atlases are scheduled to be operational at Warren AFB, Wyo., and two Polaris submarines are scheduled to be on station somewhere in the seas off Russia.

Titan is scheduled to follow Atlas into operational

ATLAS *(Air Force)*

Military designation: SM-65
Type: ICBM surface-to-surface (fixed base)
Status: Operational
Prime contractor: Convair-Astronautics Division, General Dynamics Corp.
Performance: Range—more than 8000 n. miles. Speed—about 18,000 mph. Apogee—about 600 n. miles.
Frame: System contractor—Convair. Length—82.5 ft. Diameter—10 ft. Launch weight—260,000 lbs. Material (major)—stainless steel.
Guidance: System contractor: GE/Burroughs; Bosch Arma. Type—all inertial later models; radio-inertial command early models.
Booster: System contractor—Rocketdyne. Propellant—LOX and RP-1. Thrust—165,000 lbs. each of two boosters.
Sustainer: System contractor—Rocketdyne. Propellant—LOX and kerosene. Thrust—60,000 lbs.
Re-entry Vehicle: System contractor—General Electric/Avco. Warhead type—nuclear.
Ground support equipment: Launcher—Convair. Fueling—Arthur D. Little Co. Handling and service—Goodyear Aircraft. Transport vehicles—Goodyear Aircraft.
Remarks: Atlases with in-silo launch capability to be deployed beginning with squadron 8.

DEPLOYMENT

Squadrons planned: 13
Bases planned: 10
Squadron strength: 6 to 12 missiles
Initially operational: Sept. 9, 1959 at Vandenberg AFB, Calif.
Total number of missiles: 129

Squadron Locations

Vandenberg AFB, Lompoc, Calif. One squadron—6 missiles, soft, non-dispersed
Warren AFB, Cheyenne, Wyo. Three squadrons—(1) 6 missiles, soft, non-dispersed; (2) 9 missiles, soft, semi-dispersed; (3) 9 missiles, semi-hard, dispersed
Offutt AFB, Omaha, Neb. One squadron—9 missiles, semi-dispersed, soft
Fairchild AFB, Spokane, Wash. One squadron—9 missiles, dispersed semi-hard
Forbes AFB, Topeka, Kans. One squadron—9 missiles, dispersed, semi-hard
Schilling AFB, Salina, Kans. One squadron—12 missiles, dispersed, hard
Lincoln AFB, Lincoln, Neb. One squadron—12 missiles, dispersed, hard
Altus AFB, Altus, Okla. One squadron—12 missiles, dispersed, hard
Dyess AFB, Abilene, Kans. One squadron—12 missiles, dispersed, hard
Walker AFB, Roswell, N.M. One squadron—12 missiles, dispersed, hard
Plattsburgh AFB, Plattsburgh, N.Y. One squadron—12 missiles, dispersed, hard

←

An Atlas blasts off from a pad at Patrick AFB, Fla., in one of many successful shots of first operational U. S. ICBM.

MISSILES

service in mid-1961; Minuteman a year later. By 1965, the total of U.S. strategic missiles is expected to reach more than 1000—not counting air-launched Hound Dogs and Sky Bolts.

Two major trends have emerged: American strategic power is being vested mainly in mobile systems and large numbers of extremely hard, fixed bases that are widely dispersed. Which approach will be the dominant one was still to be determined at the beginning of the summer of 1960.

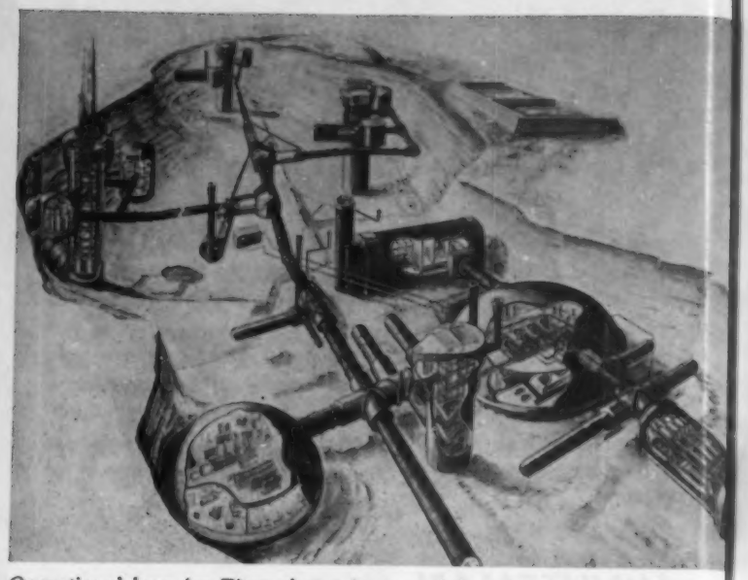
The Navy continued to press for the construction of a fleet of 45 Polaris-launching submarines, but the Administration maintained its position that if all tests proved to be successful 1961 would be time enough to accelerate the sub-building program. Meantime, the Air Force received authority to enlarge somewhat six Atlas squadrons and pushed ahead with its Minuteman and Sky Bolt programs.

Mobility vs. Fixed Bases remained a problem for the new Administration.

MINUTEMAN (Air Force)

Military designation: SM-80
Type: ICBM surface-to-surface (fixed base and mobile)
Status: R&D
Major contractor: Boeing Airplane Co.
Performance: Range—5500 n. miles. Speed—more than 15,000 mph. Apogee—about 600 miles.
Deployment: Squadrons planned—about 14 (9 in fixed bases and about 5 on trains). Squadron strength—about 50 in silo-based units and 30 to 50 in train-based units. Trains per squadron—10. Initially operational—mid-1962. Total number of missiles—about 600. Squadron locations — Malmstrom AFB, Great Falls, Mont. (3 squadrons dispersed, hard, in-silo launched).
Frame: System contractor—Boeing. Length—about 60 ft. Diameter—about 6 ft. Launch weight—about 65,000 lbs. Material (major)—steel (first two stages), titanium or plastic (third stage).
Guidance: System contractor—Autonetics. Type—all inertial.
Booster: System contractor—Thiokol. Propellant — solid. Thrust—about 160,000 lbs.
Second stage: System contractor—Aerojet-General. Propellant—solid.
Third stage: System contractor—Aerojet or Hercules Powder. Propellant—solid.
Re-entry vehicle: System contractor — Avco. Warhead type—nuclear.
Ground support equipment: Launcher—Boeing. Handling and service—Boeing. Transport vehicles—Boeing.

ABOVE: Looking down the throat of a Minuteman test silo.
BELOW: Full-scale Minuteman silo test missile on Trailer.



Operational base for Titan shown in an artist's cutaway conception. There will eventually be 10 such bases, 14 squadrons.

TITAN (Air Force)

Military designation: SM-68
Type: ICBM surface-to-surface (fixed base)
Status: R&D
Prime contractor: Martin Co.
Performance: Range—more than 5500 n. miles. Speed—1700 mph. Ceiling—about 600 miles.
Frame: System contractor—Martin. Length—98 ft. Diameter (max.)—10 ft. Launch weight—220,000 lbs. Material (major)—2014K aluminum.
Guidance: System contractor—Bell Telephone Laboratories/Sperry-Rand, A. C. Spark Plug. Type—radio inertial first six squadrons; later squadrons all inertial.
Booster: System contractor—Aerojet General. Propellant—LOX and RP-1. Thrust—300,000 lbs.
Sustainer: System contractor—Aerojet General. Propellant—LOX and RP-1. Thrust—80,000 lbs.
Re-entry vehicle: System contractor — Avco. Warhead type—nuclear.
Ground support equipment: Launcher—Martin. Fueling—Air Products/Cambridge Corp. Handling and service—Martin. Transport vehicles—North American Aviation, Douglas.
Remarks: Longer range Titan II will have a storable propellant and will be launched from its underground silo. Titan II will be deployed with Squadron 7.

DEPLOYMENT

Squadrons planned: 14
Bases planned: 10
Squadron strength: 9 missiles
Initially operational: July 1961
Total number of missiles: 126

Squadron Locations

Lowry AFB, Denver, Colo. Two squadrons — semi-dispersed, hard, elevated to surface for launching.
Ellsworth AFB, Rapid City, S.D. One squadron — semi-dispersed, hard, elevated to surface for launching.
Mountain Home AFB, Mountain Home, Idaho. One squadron —semi-dispersed, hard, elevated to surface for launching
Larson AFB, Moses Lake, Wash. One squadron — semi-dispersed, hard, elevated to surface for launching
Beale AFB, Marysville, Calif. One squadron — semi-dispersed, hard, elevated to surface for launching
Davis-Monthan AFB, Tucson, Ariz. Two squadrons—dispersed, hard, in-silo launched
McConnell AFB, Wichita, Kans. Two squadrons — dispersed, hard, in-silo launched
Little Rock AFB, Little Rock, Ark. Two squadrons—dispersed, hard, in-silo launched

←

Titan takes off from its launching facility at Patrick AFB.

POLARIS (Navy)

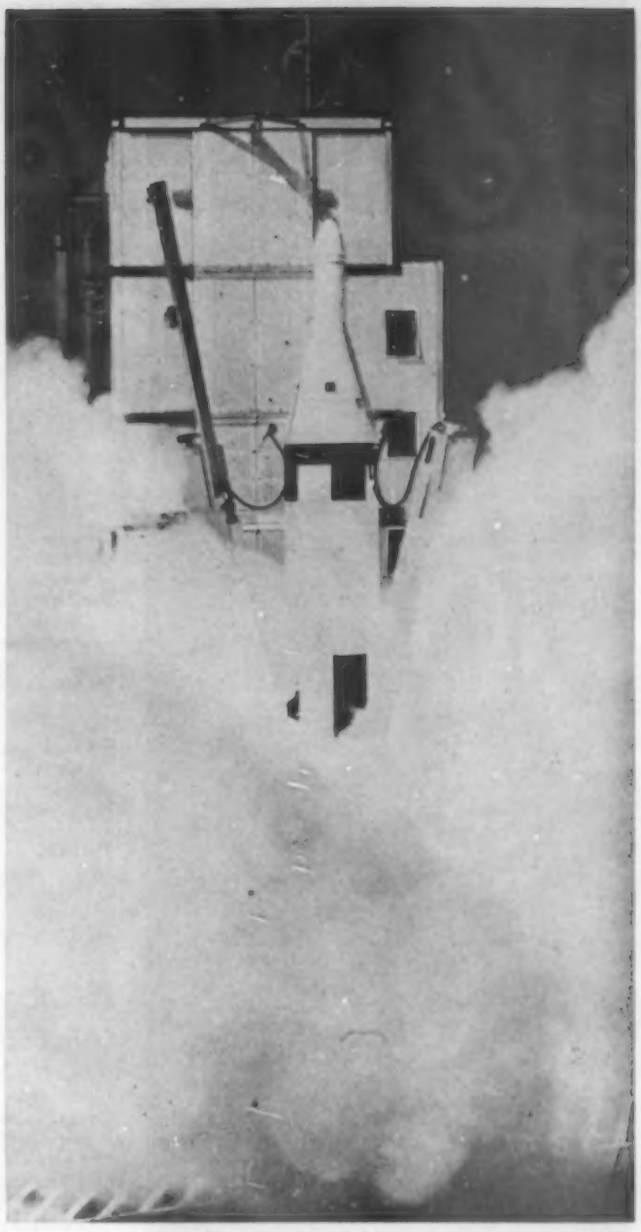
Military designation: FBM
Type: Submarine or surface ship-launched IRBM surface-to-surface (mobile)
Status: R&D
Prime contractor: Lockheed Missile Systems Division, Lockheed Aircraft Corp.
Performance: Range—1200 n. miles. Speed—about 8000 mph. Apogee—about 400 miles.
Frame: System contractor—Lockheed. Length—28 ft. Diameter—4.5 ft. Launch weight—28,000 lbs. Material (major)—steel
Guidance: System contractor—General Electric/MIT. Type—all inertial.
Booster: System contractor—Aerojet-General. Propellant—solid. Thrust—about 100,000 lbs.
Sustainer: System contractor—Aerojet-General. Propellant—solid.
Fire control: System contractor—General Electric.
Navigation: System contractor—Sperry-Gyroscope/Autonetics. Type—inertial (SINS).
Re-entry vehicle: System contractor—Lockheed. Warhead type—nuclear.
Ground support equipment: Launcher — Westinghouse. Handling and service—Westinghouse, Lockheed. Transport vehicles—Lockheed.
Remarks: Advanced 1500 n. mile and 2500 n. mile models under development. NATO nations may purchase for deployment as land-based NATO IRBM.

DEPLOYMENT

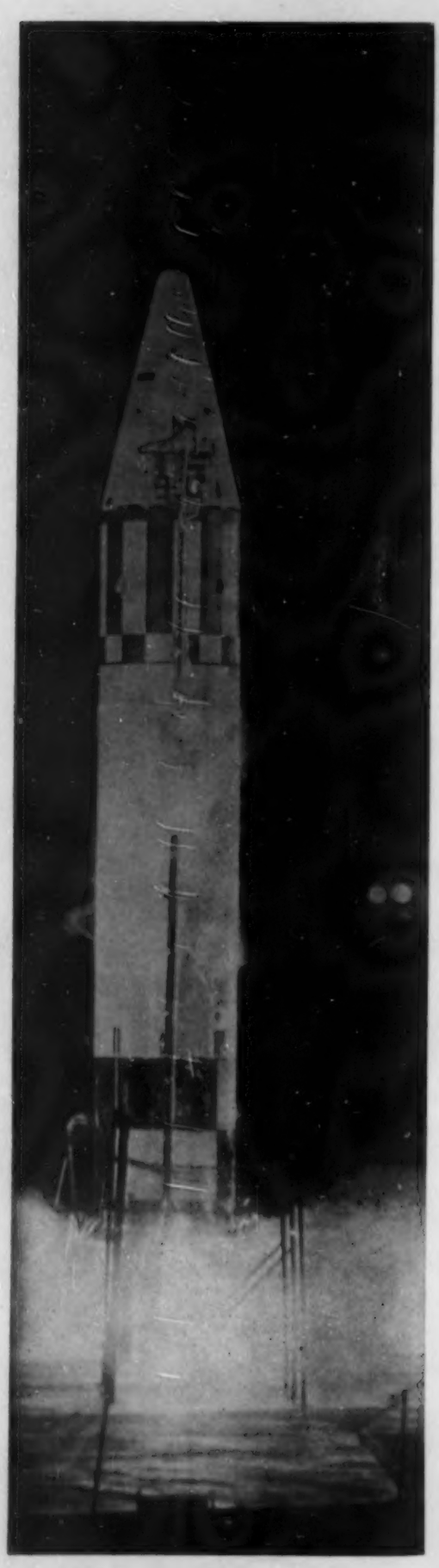
Missile-launching nuclear-powered submarines planned: about 45.
Submarines authorized part or whole: 21
Missiles per submarine: 16
Initially operational: Fall, 1960.
Total number of missiles (authorized): 336.

Polaris Submarines

George Washington 380 ft. 5600 tons commissioned 1960 Electric Boat
Patrick Henry 380 ft. 5600 tons commissioned 1960 Electric Boat
Theodore Roosevelt 380 ft. 5600 tons commissioned 1960 Mare Island
Robert E. Lee 380 ft. 5600 tons commissioned 1960 Newport News Ship
Abraham Lincoln 380 ft. 5600 tons commissioned 1960 Portsmouth Naval
Ethan Allen 410 ft. 6900 tons launching 1960 Electric Boat
Sam Houston 410 ft. 6900 tons launching 1961 Newport News Ship
Thomas A. Edison 410 ft.. 6900 tons launching 1961 Electric Boat
John Marshall 410 ft. 6900 tons launching 1961 Newport News Ship
Administration plans call for laying three more keels in FY 1961



ABOVE: A land based launching of a Polaris test vehicle.
BELOW: Nuclear-powered Patrick Henry, second Polaris sub.



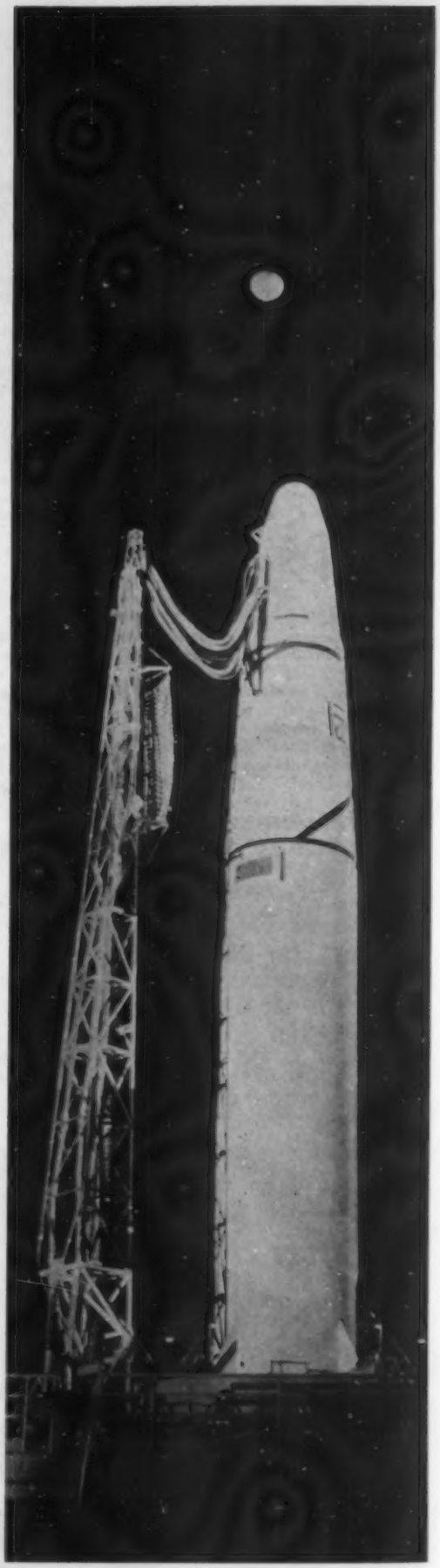
JUPITER

JUPITER
(Air Force-Army)

Military designation: SM-78
Type: IRBM surface-to-surface (fixed base or mobile)
Status: Operational
Prime contractor: Chrysler Corp.
Performance: Range—1500 n. miles. Speed—10,000 mph. Apogee—380 miles.
Deployment: Location—Italy and Turkey. Initially operational in Italy and Turkey—1960. Total squadrons planned—two in Italy; one in Turkey. Total bases—three. Squadron strength—15 missiles. Total missiles—15.
Frame:. System contractor—Chrysler. Length—58 ft. Diameter—8.75 ft. Launch weight—105,000 lbs. Material (major)—aluminum.
Guidance: System contractor—Ford Instrument. Type—all inertial.
Booster: System contractor—North American Aviation. Propellant—LOX and kerosene. Thrust—150,000 lbs.
Re-entry vehicle: System contractor—Goodyear/C.T.L. Warhead type—nuclear.
Ground support equipment: Launcher—Chrysler. Fueling—Chrysler. Handling and service—Chrysler. Transport vehicles—Chrysler.
Remarks: Jupiter was developed by the Army Ballistic Missile Agency and turned over to the Air Force for operational deployment.

THOR
(Air Force)

Military designation: SM-75
Type: IRBM surface-to-surface
Status: Operational
Prime contractor: Douglas Aircraft Co., Inc.
Performance: Range—1500 n. miles. Speed—10,000 mph. Apogee—about 400 miles.
Deployment: Location—Great Britain (military); Vandenberg AFB and Cape Canaveral (R&D and training). Initially operational in England—1959. Total squadrons—four. Total bases—four. Squadron strength—15 missiles. Total missiles deployed—60.
Frame: System contractor—Douglas. Length—65 ft. Diameter—8. Launch weight—110,000 lbs. Material (major)—aluminum.
Guidance: System contractor—A.C. Spark Plug. Type—all inertial.
Booster: System contractor—Rocketdyne. Propellant—LOX and JP4. Thrust—150,000 lbs.
Re-entry vehicle: System contractor—General Electric. Warhead type—nuclear.
Ground support equipment: Launcher—Food Machinery. Fueling—Daco. Transport vehicles—Fruehauf.



THOR

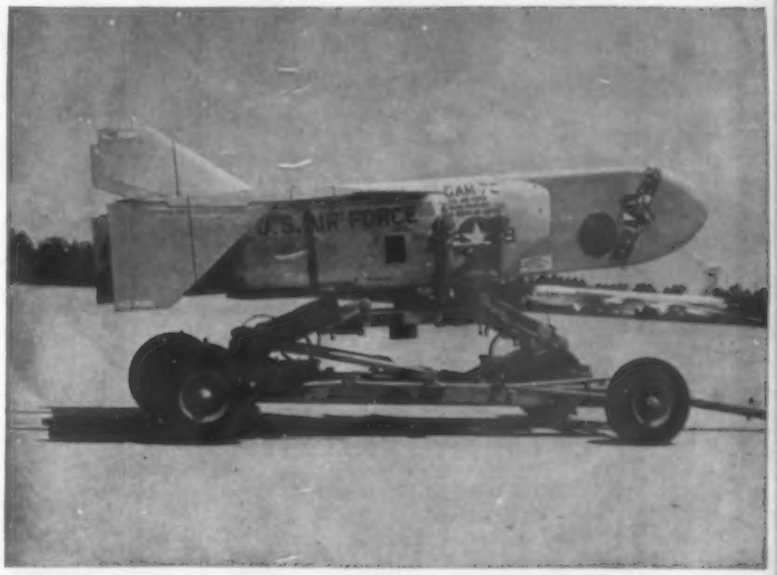
HOUND DOG
(Air Force)

Military designation: GAM-77
Type: Air-breathing air-to-surface
Status: Operational
Prime contractor: North American Aviation, Inc.
Performance: Range—more than 500 n. miles. Speed—about Mach 2. Apogee — air-breather.
Deployment: Location—SAC B-52 bases in U.S. and overseas. Initially operational—1960. Total deployed missiles—expected to exceed 400.
Frame: System contractor—North American. Length—42.5 ft. Diameter—28 in. Wing span—12 ft. Launch weight—about 10,000 lbs.
Guidance: System contractor—Autonetics. Type—all inertial.
Powerplant: System contractor—Pratt & Whitney. Engine—J-52 turbo-jet. Thrust—7500 lbs.
Re-entry vehicle: Type warhead—nuclear.
Remarks: Hound Dog was developed as an interim weapon for use while the Air Force is developing the far superior Sky Bolt.

HOUND DOG

QUAIL (Air Force)

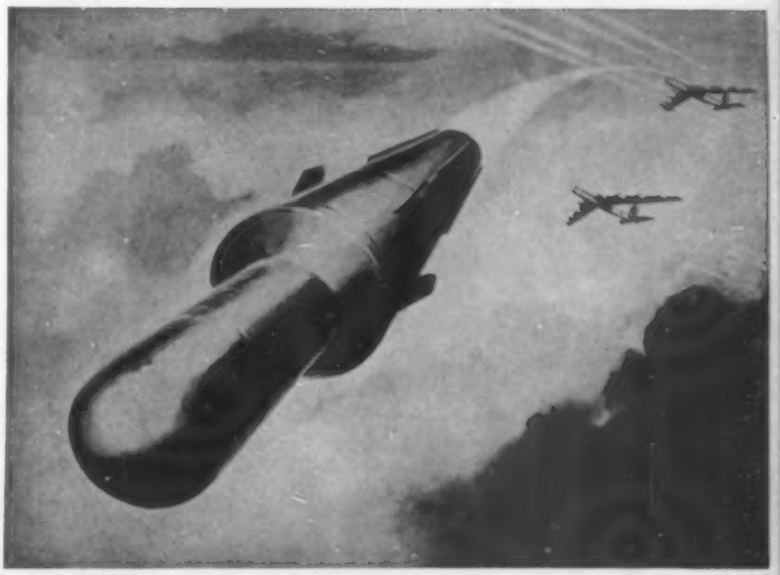
Military designation: GAM-72
Type: Air-launched missile ECM decoy
Status: R&D
Prime contractor: McDonnell Aircraft Co.
Performance: Range—about 200 n. miles. Speed—near sonic. Ceiling—more than 50,000 ft.
Deployment: Location—SAC air bases. Initially operational—1960.
Frame: System contractor—McDonnell. Length—13 ft. Wing span—65 in. Launch weight—about 1100 lbs. Material (major)—reinforced plastics.
Guidance: System contractor—Summers Gyro. Type—gyro autopilot.
Powerplant: System contractor—General Electric. Engine—J85-7 turbo-jet. Thrust—2000 lbs.
Payload: System contractor—Ramo-Wooldridge. Type—electronic counter measures.
Ground support equipment: System contractor—Bell Aircraft.
Remarks: Quail is designed to serve a dual role as a decoy for a strategic bomber and as a vehicle to carry ECM equipment.



QUAIL

SKY BOLT (Air Force)

Military designation: GAM-87A
Type: air-to-surface ballistic missile (ALBM)
Status: R&D
Prime contractor: Douglas Aircraft Co.
Performance: Range—1000 n. miles. Speed—hypersonic.
Deployment: Location — SAC and TAC air bases. Also RAF bases in England. (Sky Bolts to be launched from variety of aircraft besides bombers—particularly tankers and transports.) Initially operational—about 1964.
Frame: System contractor—Douglas.
Guidance: System contractor—Nortronics. Type—stellar-inertial.
Booster: System contractor—Aerojet. Propellant—solid.
Sustainer: System contractor—Aerojet. Propellant—solid.
Re-entry vehicle: System contractor — General Electric. Warhead type—nuclear.



SKY BOLT

SLAM (Air Force)

Type: Intercontinental nuclear-powered missile
Status: Study
Prime contractor: No contractor announced
Performance: Range—global. Speed—supersonic. Ceiling—low altitude.
Sustainer: System contractor—R&D being conducted by the Atomic Energy Commission, N.A.A. International and Marquardt (Project Pluto). Engine—nuclear-powered ramjet.
Payload: Warhead type—nuclear.
Remarks: Convair, North American and Chance Vought are principal competitors in studies submitted to the Air Force.

REGULUS I

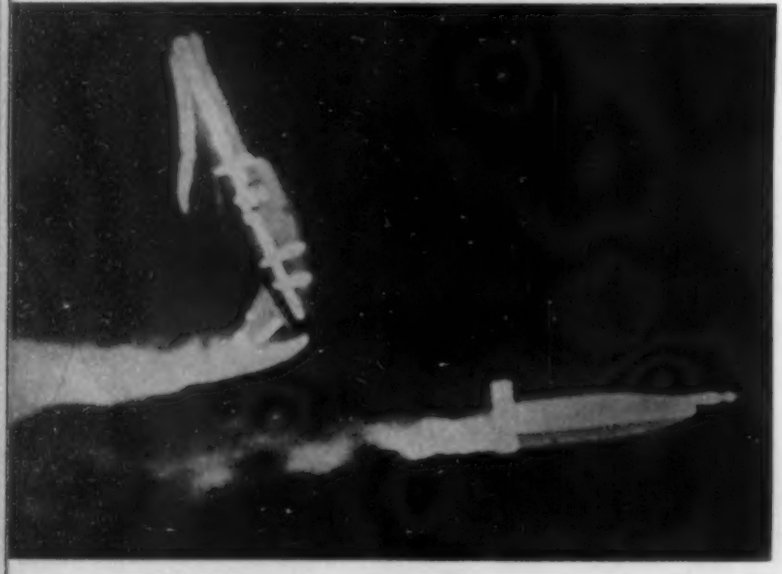
REGULUS II

REGULUS I (Navy)

Military designation: SSM-N-8
Type: Air-breathing surface-to-surface (seaborne)
Status: Operational
Prime contractor: Chance Vought Aircraft, Inc.
Performance: Range—500 n. miles. Speed—about 600 mph. Ceiling—about 40,000 ft.
Deployment: Location—aboard five submarines (Growler, Barbero, Grayback, Tunny and nuclear-powered Halibut) and two cruisers (Los Angeles and Helena). Initially operational—1954.
Frame: System contractor—Chance Vought. Length—34 ft. Diameter—4.5 ft. Wingspan—21 ft. Launch weight—14,000 lbs. Material (major)—aluminum.
Guidance: System contractor—Sperry. Type—radio command.
Booster: System contractor—Aerojet. Propellant—solid. Number—two. Thrust—33,000 lbs. each.
Sustainer: System contractor—Allison. Engine—J33-18 turbo-jet. Thrust—4600 lbs.
Payload: Warhead type—nuclear.
Ground support equipment: Launcher—Fruehauf. Fueling—Chance Vought. Handling and service—Chance Vought. Transport vehicles—Fruehauf.
Remarks: Last of more than 500 Regulus I's were delivered in 1958. Production terminated. Warhead considered large.

REGULUS II (Navy)

Military designation: SM-N-9A
Type: Air-breathing surface-to-surface (seaborne)
Status: Operational as target drone.
Prime contractor: Chance Vought Aircraft, Inc.
Performance: Range—more than 800 n. miles. Speed—more than Mach 2. Ceiling—more than 65,000 ft.
Deployment: Location—PMR, Point Mugu, Calif., and Eglin Test Range, Fla. Initially operational: March, 1959. Total squadrons planned: Two.
Frame: System contractor—Chance Vought. Length—59.5 ft. Diameter: 50 in. Wingspan—20 ft. Launch weight—up to 30,000 lbs. Material (major) aluminum.
Guidance: System contractor—Bell. Type—radio command.
Booster: System contractor—Aerojet and Rocketdyne. Propellant—solid. Thrust—115,000 and 130,000 lbs.
Sustainer: System contractor—General Electric. Engine—J-79-3 turbo-jet. Thrust—more than 10,000 lbs.
Payload: Warhead type for military version—nuclear.
Ground support equipment: Launcher—Fruehauf. Fueling—Chance Vought. Handling and service—Chance Vought. Transport vehicles—Fruehauf.
Remarks: The Navy cancelled the Regulus II weapon system in December, 1958, on grounds that the missile had become obsolescent. The missile was in production.



SNARK

SNARK (Air Force)

Military designation: SM-62
Type: Air-breathing intercontinental guided missile
Status: Operational
Prime contractor: Northrop Corp.
Performance: Range—5500 n. miles. Speed—Mach 0.94. Ceiling—more than 50,000 ft.
Deployment: Location—702nd Strategic Missile Wing, Presque Isle, Maine. Initially operational—1959. Total squadrons planned—one. Total bases planned—one. Squadron strength—about 15.
Frame: System contractor—Northrop. Length—67.2 ft. Diameter—five ft. Wing span—42 ft. Launch weight—59,936 lbs. Material (major)—aluminum.
Guidance: System contractor—Northrop. Type—stellar-inertial.
Booster: System contractor—Allegany Ballistic Lab. Type—solid. Number—two. Thrust—33,000 lbs. each.
Sustainer: System contractor—Pratt & Whitney. Engine—J-57 turbojet. Thrust—10,500 lbs.
Payload: Warhead type—nuclear.
Ground support equipment: Launcher—Northrop. Fueling—Northrop. Handling and service—Northrop. Transport vehicles—Northrop.
Remarks: Capable of carrying very large warhead.

TACTICAL MISSILES

The development of advanced tactical missiles with ranges from several miles to 1000 miles is expected to call on the best talent of the Missile/Space Industry in the 1960's.

New tactical missiles already are revolutionizing military thinking.

The individual soldier of the very near future will have tremendous power in his hands with the deployment of nuclear-tipped Davy Crocketts. Highly mobile Little Johns and Sergeants will give the infantryman artillery support that will be far more powerful and effective than anything ever seen on a battlefield.

At the same time, the stand-off air-to-surface missile is expected to extend the life of military planes into the late 1960's. Such missiles as Corvus and Bullpup will enable aircraft to strike at heavily-defended targets that it would be nearly certain death to attack.

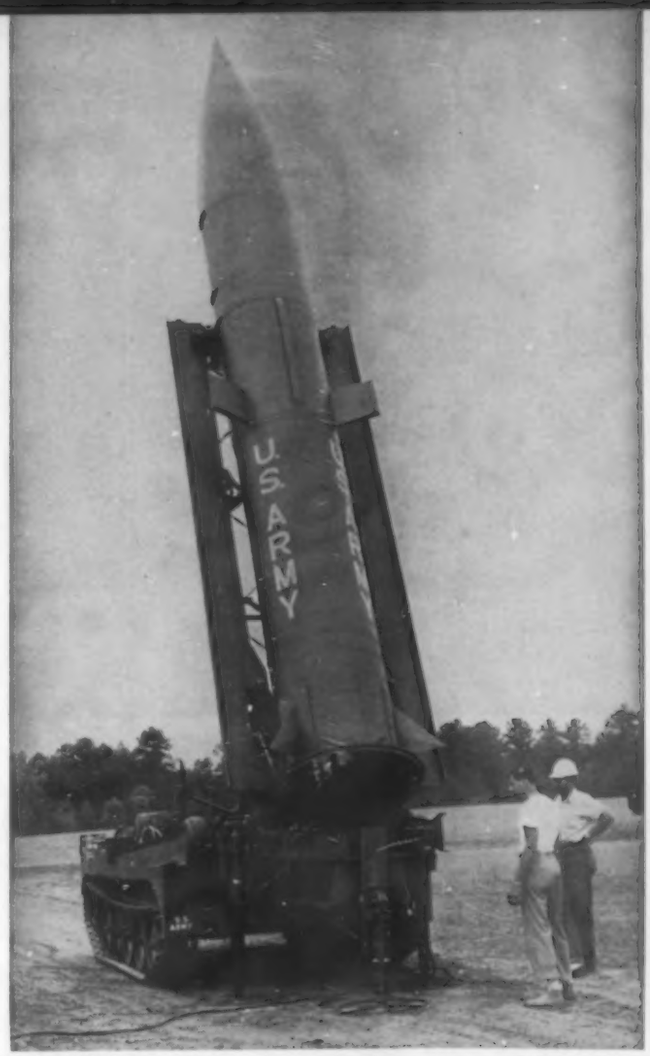
SURFACE-TO-SURFACE

PERSHING (Army)

Type: Surface-to-surface
Status: R&D
Prime contractor: The Martin Co.
Performance: Range—350 n. miles. Speed—supersonic.
Deployment: Location—to replace Redstone. Initially operational: about late 1961.
Frame: System contractor—Martin. Length—about 32 ft. Diameter—40 in.
Guidance: System contractor—Bendix. Type—inertial.
Booster: System contractor—Thiokol. Propellant—solid.
Sustainer: System contractor—Thiokol. Propellant—solid.
Payload: Warhead type—nuclear.
Ground support equipment: Transporter-erector-launcher—Thompson-Ramo Wooldridge. Handling and services—Vehicles—Food Machinery.
Remarks: Range could be greatly increased if desired. First R&D launching Feb. 25, 1960 from Cape Canaveral, Fla.

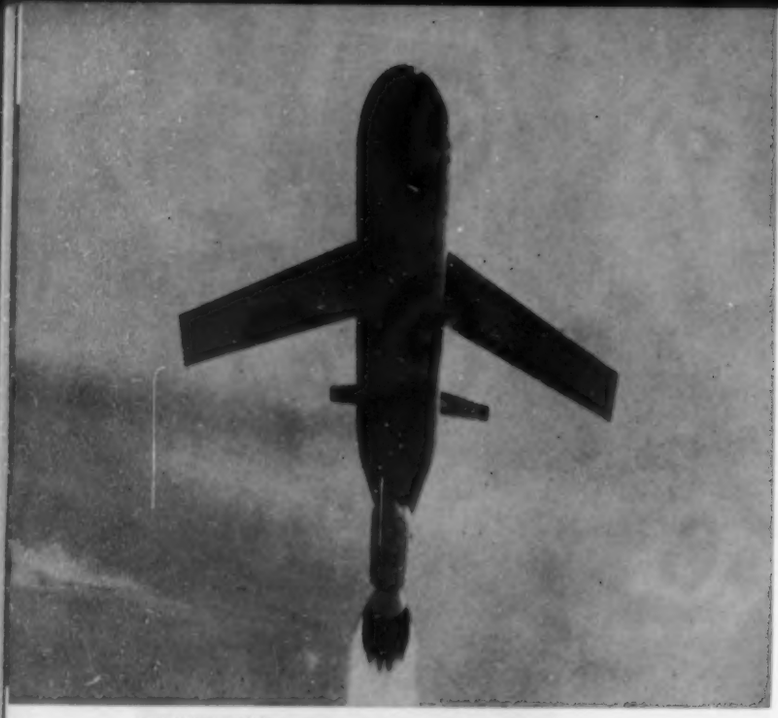
REDSTONE (Army)

Military designation: SXXM-A14
Type: Surface-to-surface
Status: Operational
Prime contractor: Chrysler Corp.
Performance: Range—200 n. miles. Speed—3800 mph. Apogee—55 miles.
Deployment: Location—U.S. troops in Germany. Initially operational—1958.
Frame: System contractor—Reynolds Metals. Length—70 ft. Diameter—5.5 ft. Launch weight—62,000 lbs. Material (major)—aluminum.
Guidance: System contractor—Ford Instrument. Type—inertial.
Booster: System contractor—North American Aviation. Propellant—Thrust—78,000 lbs.
Payload: Warhead type—nuclear or HE.
Ground support equipment: Launcher—Chrysler. Fueling—Chrysler. Handling and service—Chrysler. Transport vehicles—Chrysler.
Remarks: To be replaced by Pershing. Redstones are to be used in the Mercury program by NASA for early equipment test flights.



PERSHING

REDSTONE



MATADOR

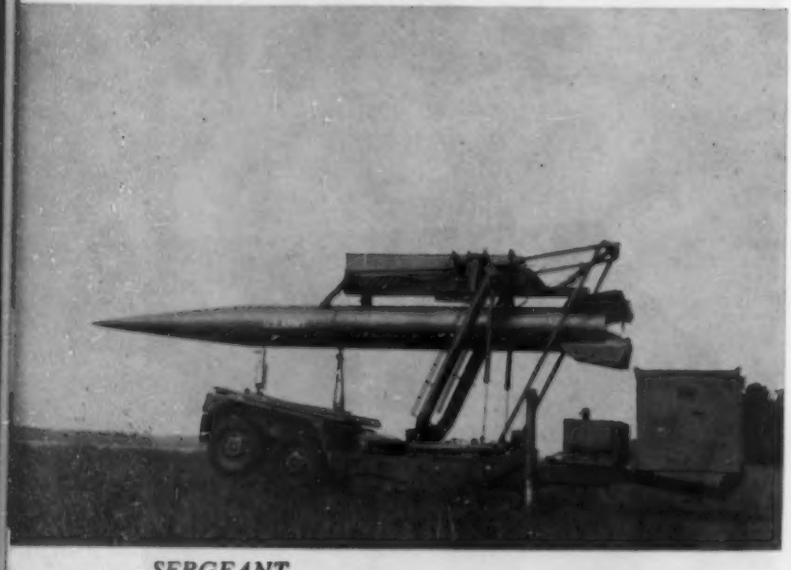
MATADOR (Air Force)

Military designation: TM-61C
Type: Air-breathing surface-to-surface
Status: Operational
Prime contractor: The Martin Co.
Performance: Range—500 n. miles. Speed—about 650 mph. Ceiling—more than 40,000 ft.
Deployment: Location — U.S. troops in West Germany, Far East. Also in hands of NATO allies. Initially operational: October, 1951. Total divisions—three. Divisional strength—about 50.
Frame: System contractor—Martin. Length—39.6 ft. Diameter—54 in. Wingspan—28.7 ft. Launch weight—12,500 lbs. Material (major)—aluminum and magnesium.
Guidance: System contractor—Air Force. Type—radar control
Booster: System contractor—Thiokol. Propellant — solid (JATO). Thrust—57,000 lbs.
Sustainer: System contractor—Allison. Engine—J-33-37 turbo jet. Thrust—4200 lbs.
Payload: Warhead type—nuclear or HE.
Ground support equipment: Launcher—Martin. Fueling—Martin. Handling and service—Martin. Transport vehicles—Martin.
Remarks: Relatively mobile Matadors are being replaced by more advanced Maces. Matadors in West Germany are being turned over to German troops.

MACE

MACE (Air Force)

Military designation: TM-76A and TM-76B
Type: Air-breathing surface-to-surface
Status: TM-76A operational. TM-76B flight-testing.
Prime contractor: The Martin Co.
Performance: Range—(A) more than 650 n. miles. (B) more than 1200 n. miles. Speed—(A) more than 650 mph. (B) same but supersonic in terminal dive. Ceiling—more than 40,000 ft.
Deployment: Location—(A) U.S. troops in West Germany. Initially operational—(A) 1960. Total divisions—at least two. Divisional strength—about 50.
Frame: System contractor—Martin. Length—44 ft. Diameter—54 in. Wingspan—22.9 ft. Launch weight—15,500 lbs. Material (major)—aluminum and magnesium
Guidance: System contractor—(A) Goodyear. (B) A.C. Spark Plug. Type: (A) ATRAN map-matching. (B) inertial.
Booster: System contractor—Thiokol. Propellant — solid (JATO). Thrust—100,000 lbs.
Sustainer: System contractor—Allison. Engine — J-33-41. Thrust—5200 lbs.
Ground support equipment: Launcher—(A) Goodyear. (B) Martin. Fueling—Martin. Handling and service—(A) Goodyear, Martin, Four Wheel Drive Auto Co. (B) Martin, A.C. Spark Plug. Transport vehicles—(A) Four Wheel Drive. (B) Martin.



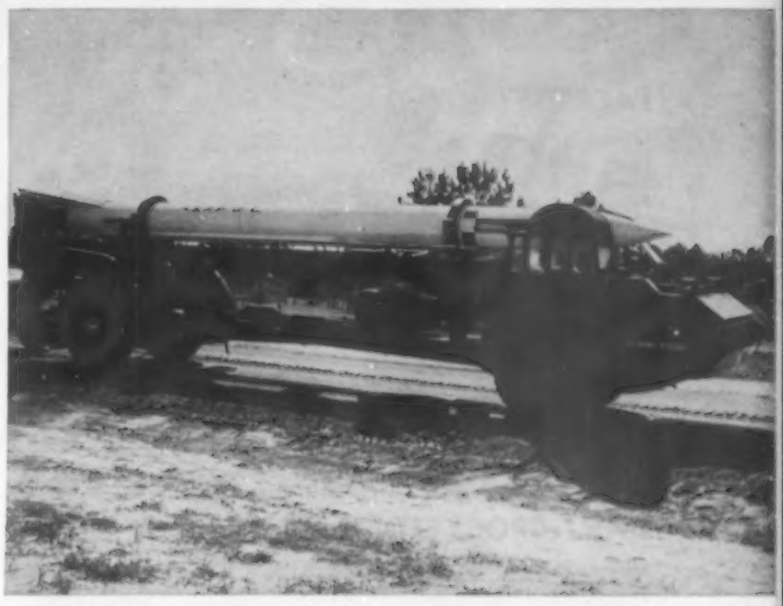
SERGEANT

SERGEANT (Army)

Military designation: SSM-A26
Type: Surface-to-surface
Status: Nearly operational
Prime contractor: Sperry Utah Engineering Lab.
Performance: Range—75 miles. Speed—supersonic.
Deployment: Location—to replace Corporal. Initially operational—1960.
Frame: System contractor—Sperry. Length—36 ft. Diameter—31 in. Launch weight—10,000 lbs. Material (major) — steel and aluminum.
Guidance: System contractor—Sperry. Type—inertial.
Booster: System contractor—Sperry. Propellant—solid. Thrust—about 55,000 lbs.
Payload: Warhead type—nuclear or HE.
Ground support equipment: Launcher—AMF. Fueling—Thiokol. Handling and service—Sperry. Transport vehicles—Fruehauf.

CORPORAL (Army)

Military designation: M-2
Type: Surface-to-surface
Status: Operational
Prime contractor: Firestone Tire & Rubber Co./Gilfillan Bros.
Performance: Range—75 miles. Speed—Mach 3.
Deployment: Location — U.S. troops in Europe. Battalion strength—two launchers; two batteries (one firing, the other service). Initially operational—late 1953.
Frame: System contractor—Firestone. Length—45 ft. Diameter—30 in. Launch weight—11,000 lbs. Material (major)—steel.
Guidance: System contractor—Gilfillan. Type—preset and command.
Booster: System contractor—Ryan. Propellant—nitric acid and aniline.
Payload: Warhead type—nuclear or HE.
Ground support equipment: Launcher—Firestone. Fueling—Firestone. Handling and service—Firestone.
Remarks: To be replaced by the solid-propelled Sergeant.



CORPORAL

HONEST JOHN

HONEST JOHN (Army)

Military designation: M-31
Type: Surface-to-surface
Status: Operational
Prime contractor: Douglas Aircraft Co./Emerson Electric
Performance: Range—12 miles. Speed—Mach 1.7.
Deployment: Location — U.S. forces in continental United States, Europe and the Far East. Also in the hands of U.S. NATO allies. Initially operational—late 1953. Battalion strength—four launchers.
Frame: System contractor—Douglas/Emerson. Length—27 ft. Diameter—30 in. Launch weight—5800 lbs. Material (major) steel.
Guidance: Type—free-flight ballistic missile.
Booster: System contractor—Hercules Powder. Propellant—solid.
Spin rockets: System contractor—Thiokol. Propellant—solid.
Payload: Warhead type—nuclear or HE.
Ground support equipment: Launcher—Rock Island Arsenal.
Remarks: Douglas is producing an Improved Honest John made of aluminum with a solid booster manufactured by Allegany Ballistic Lab. The improved version has a range of more than 12 miles, weighs 1000 lbs. less and is three inches shorter.

LITTLE JOHN (Army)

Military designation: M-51
Type: Surface-to-surface
Status: Operational
Prime contractor: Emerson Electric Co.
Performance: Range—10 miles. Speed—supersonic.
Deployment: Location—missile in hands of training units in the United States. Initially operation—1960. Battalion strength—four launchers.
Frame: System contractor—Emerson Electric. Length—14 ft. 5 in. Diameter—12.5 in. Launch weight—760 lbs. Material (major)—steel and aluminum.
Guidance: Type—free-flight ballistic missile.
Booster: System contractor—Army Ordnance Missile Command/Hercules Powder. Propellant—solid.
Payload: Warhead type—nuclear or HE.
Ground support equipment: Launcher—Rock Island Arsenal.
Remarks: A highly mobile and easily airlifted missile.

LITTLE JOHN IV

LACROSSE (Army)

Military designation: M4E2
Type: Surface-to-surface
Status: Operational
Prime contractor: The Martin Co.
Performance: Range—20 miles. Speed—transonic.
Deployment: Location—Two U.S. battalions in West Germany; five more in training in the United States. Initially operational—1959. Total battalions—seven. Battalion strength—four mobile launchers.
Frame: System contractor—Martin. Length—19 ft. Diameter—20.5 in. Launch weight—2300 lbs.
Guidance: System contractor—Martin. Type—command.
Booster: System contractor—Thiokol. Propellant—solid.
Payload: Warhead type—nuclear or HE.
Ground support equipment: Launcher—Martin. Handling and service—Martin.

LACROSSE

DAVY CROCKETT (Army)

Military designation: XM-388
Type: Surface-to-surface
Status: Nearly operational
Prime contractor: Rock Island, Ill. Arsenal
Performance: Launched from either two tube-shaped launchers (XM-28 and XM-29) of varying size for different ranges. Range is relatively short.
Deployment: Location—U.S. troops overseas and in continental United States; also NATO allies. Initially operational: about 1961.
Booster: Propellant—solid.
Payload: Warhead type—nuclear. (frational yield).
Remarks: Smaller launcher can be carried by two men. Crockett is inserted into its launcher in the same fashion as a rifle grenade. The warhead is larger than the tube.

DAVY CROCKETT

SHILLELAGH (Army)

Type: Surface-to-surface
Status: R&D
Prime contractor: Ford Aeronutronics Div.
Performance: Designed to provide heavy firepower for close-in support of troops.
Deployment: Location—to be deployed with U.S. combat troops. Initially operational—mid-1960's.
Fire control: System contractor—Raytheon
Payload: Warhead type—nuclear.
Remarks: There will be hand-carried and vehicle mounted versions.

MISSILE A (Army)

Type: Surface-to-surface
Status: R&D
Prime contractor: None announced
Performance: Range—about 10-20 miles.
Frame: Launch weight—under 500 lbs.
Remarks: The Army Rocket and Guided Missile Agency at Huntsville, Ala., is acting as systems manager for a series of components that have been under development.

M-55 (Army)

Type: Surface-to-surface
Status: Operational
Prime contractor: Norris Thermador Co.
Performance: Range—relatively short. Launched from 45-tube T-145 launcher.
Deployment: Location—U.S. combat troops in the United States and overseas. Initially operational: 1960.
Frame: Diameter—115 mm.
Guidance: Type—free-flight.
Booster: Propellant—solid.
Payload: Warhead type—chemical agents.
Remarks: The Army in FY '61 is planning to buy more than 100,000 M-55's with an undisclosed number of launchers.

ARMY MULTIPLE ROCKET LAUNCHERS

ANTI-TANK

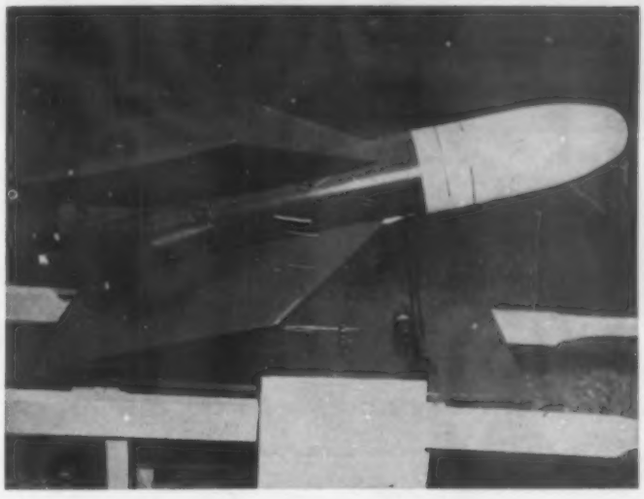
SS-10 (Army)

Type: Anti-tank
Status: Operational
Prime contractor: Nord Aviation, Paris, France; General Electric Co. (U.S. licensee)
Performance: Range—5250 ft. (effective). Speed—180 mph.
Deployment: Location—U.S. Army combat units (launched from jeeps, helicopters and other mobile vehicles). Also see Foreign Missiles section
Frame: System contractor—Nord (GE secondary source). Length—34 in. Diameter—six in. Wingspan—30 in. Launch weight—33 lbs.
Guidance: System contractor—Nord. Type—wire.
Booster: System contractor—Nord. Propellant—solid.
Payload: System contractor—Strim. Warhead type—armor-piercing HE.
Remarks: Initial U.S. Army procurement began in April, 1959. SS-10 can be carried and launched by one man.

SS-10

SS-11 (Army)

Type: Anti-tank
Status: Operational
Prime contractor: Nord Aviation, Paris, France
Performance: Range—1650-11,-500 ft. (effective). Speed—more than 400 mph.
Deployment: Location—under evaluation by Army units. Also see Foreign Missiles section.
Frame: System contractor—Nord. Length—46 in. Diameter—six in. Wingspan—20 in. Launch weight—62 lbs.
Guidance: System contractor—Nord. Type—wire.
Booster: System contractor—Nord. Propellant—solid.
Payload: System contractor—Strim. Warhead type—armor-piercing HE.



SS-11

COBRA (Marines)

Type: Anti-tank
Status: Operational
Prime contractor: Boelkow Entwicklungen, Munich, Germany, and Daystrom, Inc.
Performance: Range—5940 ft. (max.); 5280 ft. (effective). Speed—191 mph.
Deployment: Location—Marine evaluation units.
Deployment: Location—1st Marine Division, Camp Pendleton, Calif., and Marine Corps Landing Force Development Center, Quantico, Va., to conduct evaluation in 1960. Also see Foreign Missiles section
Frame: System contractor—Boelkow (Europe); not determined for U.S. Length—30.7 in. Diameter—3.9 in. Height—13.6 in. Wingspan—19 in. Launch weight—20.2 lbs. Material (major)—plastic
Guidance: System contractor—Boelkow (Europe); Daystrom (U.S.) Type—wire.
Booster: System contractor—Oerlikon (Europe). Not determined for U.S. Propellant—solid.
Payload: Warhead type—armor-piercing HE (5.5 lbs.)
Remarks: Missile can be launched and guided by one man.

COBRA

BULLPUPS ON NAVY FJ FURY

AIR-TO-SURFACE

BULLPUP (Navy and Air Force)

Military designation: ASM-N-7 and GAM-83A
Type: Air-to-surface
Status: Operational
Prime contractor: The Martin Co.
Performance: Range—three to six n. miles. Speed—supersonic.
Deployment: Location—U.S. carriers, Marine Corps units and the Tactical Air Command. Initially operational—April, 1959, aboard the Carrier Lexington.
Frame: System contractor—Martin. Length—11 ft. Diameter—about one ft. Launch weight—571 lbs. Material (major)—aluminum.
Guidance: System contractor—Martin. Type—command (visual reference).
Booster: System contractor—Allegany Ballistics Lab and Thiokol. Type—solid and packaged liquid (Guardian).
Payload: Warhead type—HE (250-1000 lb.) or nuclear.
Remarks: The Air Force originally planned a radically different version of Bullpup called White Lance, but switched to buying only slightly modified Bullpups. Bullpups are usually carried by tactical jet aircraft, but Marines also have fired a Bullpup from a helicopter.

CORVUS (Navy)

Military designation: XASM-N-8
Type: Air-to-surface
Status: Pre-operational testing
Prime contractor: Temco Aircraft Corp.
Performance: Range—more than 100 n. miles. Speed—supersonic.
Deployment: Location—designed for carrier-based aircraft. Initially operational—1960-61.
Frame: System contractor—Temco.
Guidance: System contractor—Maxson and Texas Instrument. Type—radar homing.
Booster: System contractor—Thiokol. Propellant—packaged liquid (Patriot).
Payload: Warhead type—HE or nuclear.
Remarks: First guided test flight March 15, 1960, from an A3D jet over PMR sea test area. Most information about Corvus classified, but missile is reported to be designed to penetrate highly defended areas by homing on electronic equipment such as radar.

ADVANCED TACTICAL MISSILES

Project	Contractors	Description	Status
ARM (Air Force)	No contracts announced	Air-to-surface anti-radar missile	R&D
COBRA (Navy)	No contracts announced	Anti-ship, anti-radar missile	R&D
CLAYMORE (Army)	No contracts announced	Anti-personnel missile	R&D
GPSSM (Army)	No contracts announced	General purpose surface-to-surface missile	Study
LOBBER (Army)	No contracts announced	Surface-to-surface cargo carrier; 10-15 m. range; also can drop napalm	Study
RAVEN (Navy)	No contracts announced	Air-to-surface; about 500 m. range	Study
WAGTAIL (Air Force)	Minneapolis-Honeywell-prime	Air-to-surface; solid propellant; designed to hug terrain	R&D
WILLOW (Army)	Chrysler, prime	No details available	

CORVUS

Air/Space Defense

A revolution in air defense missiles is coming quickly.

Such surface-to-air missiles as Nike-Hercules and Bomarc, along with air-to-air missiles like Sidewinder and Falcon continue to be America's main weapons against attacking aircraft.

But the emphasis is switching rapidly to defense against missiles and spacecraft.

So far, Nike-Zeus is the only U.S. anti-ICBM funded for full development. But both the Army and Navy are working on tactical anti-missile missiles. And all three services are looking ahead beyond Zeus.

America must defend itself not only against incoming missiles but also against satellites and spacecraft.

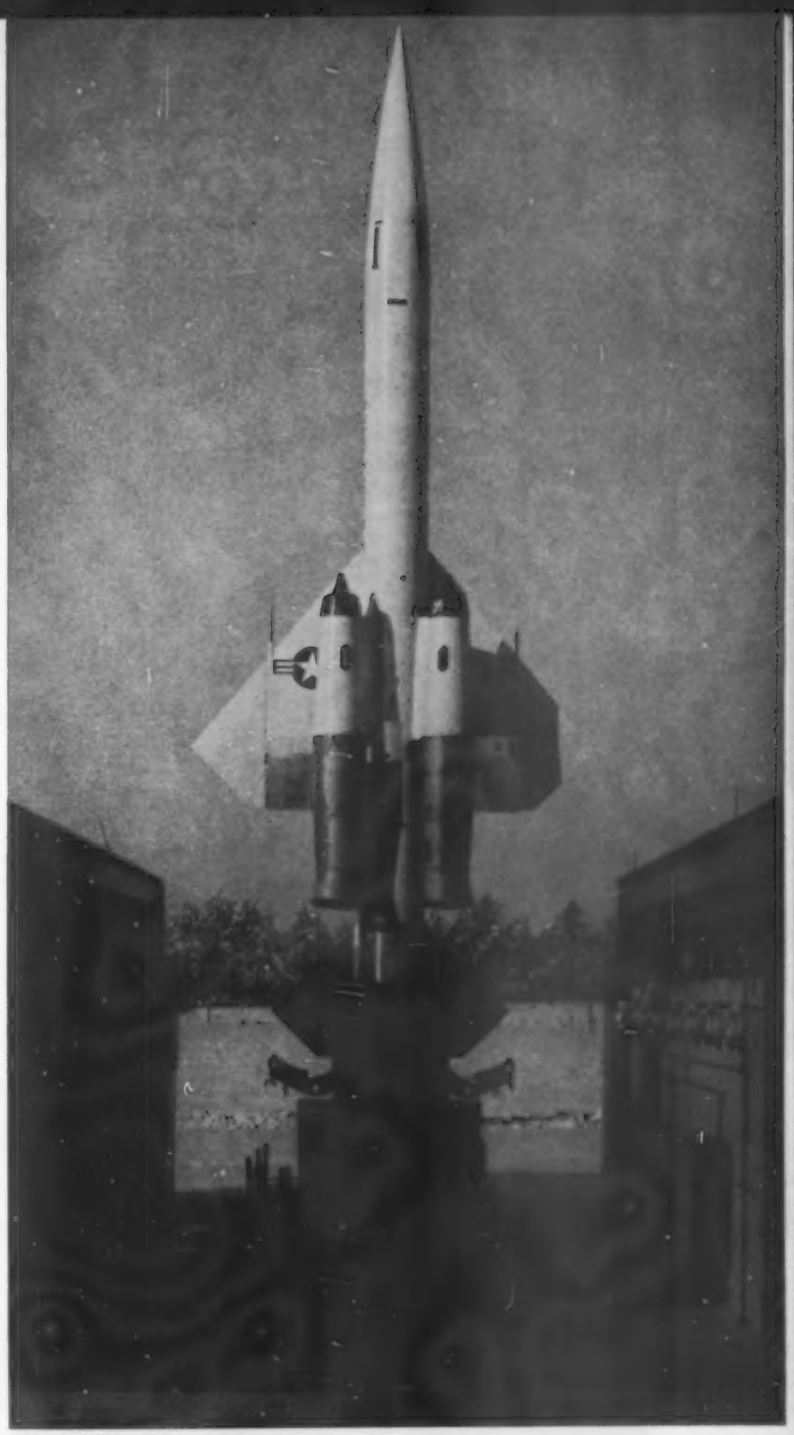
ANTI-AIRCRAFT

BOMARC A (Air Force)

Military designation: IM-99A
Type: Air-breathing surface-to-air
Status: Operational
Prime: Boeing Airplane Co.
Performance: Range—250 n. miles. Speed — supersonic. Ceiling—more than 68,000 ft.
Deployment: Location—McGuire AFB, N.J.; Suffolk County AFB, N.Y.; Otis AFB, Mass.; Dow AFB, Maine; and Langley AFB, Va. Initially operational—1959. Total bases planned—five. Total squadrons planned—five. Squadron strength—average about 40 missiles.
Frame: System contractor—Boeing. Length—47 ft. Diameter —35 in. Wingspan—18 ft. Launch weight—15,000 lbs. Material (major)—stainless steel.
Guidance: System contractor—IBM and Westinghouse. Type: command and homing radar. (IBM SAGE guides missile to vicinity of target when homing radar assumes command.)
Booster: System contractor—Aerojet. Propellant—liquid.
Sustainer: System contractor—Marquardt. Engine—(2) RJ-43 ramjets.
Payload: Warhead type—nuclear or HE.
Ground support equipment: Launcher-erector—Food Machinery.

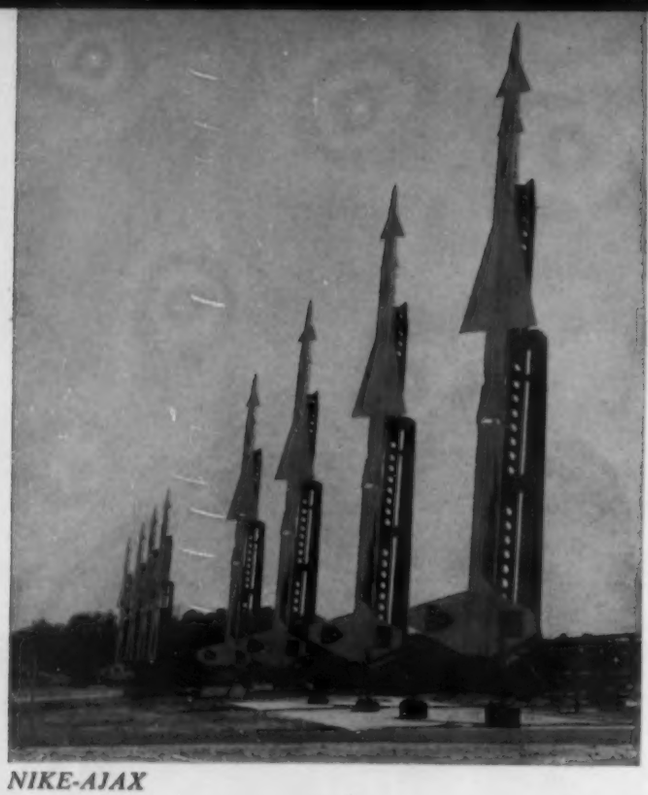
BOMARC B (Air Force)

Military designation: IM-99B
Type: Air-breathing surface-to-air
Status: R&D/production
Performance: Range—400 n. miles. Speed — supersonic. Ceiling—more than 70,000 ft.
Deployment: Location — continental United States (Duluth, Minn.; Niagara Falls, N.Y.; Kincheloe AFB, Mich.) and Canada. Initially operational: Total squadrons — (U.S.) three: (Canada) two. Total bases planned—five. Squadron strength—average about 40 missiles.
Frame: System contractor—Boeing. Length—45 ft. Diameter —35 in. Wingspan—18 ft. Launch weight—16,000 lbs. Material (major)—stainless steel.
Guidance: System contractor—IBM and Westinghouse. Type —command and radar homing. (IBM SAGE guides missile to vicinity of target when homing radar takes command.)
Booster: System contractor—Thiokol. Propellant—solid.
Sustainer: System contractor—Marquardt. Engine—(2) RJ-43 advanced ramjets.
Payload: Warhead type—nuclear or HE.
Ground support equipment: Launcher-erector—Food Machinery.
Remarks: Original number of squadrons planned was sharply cut.

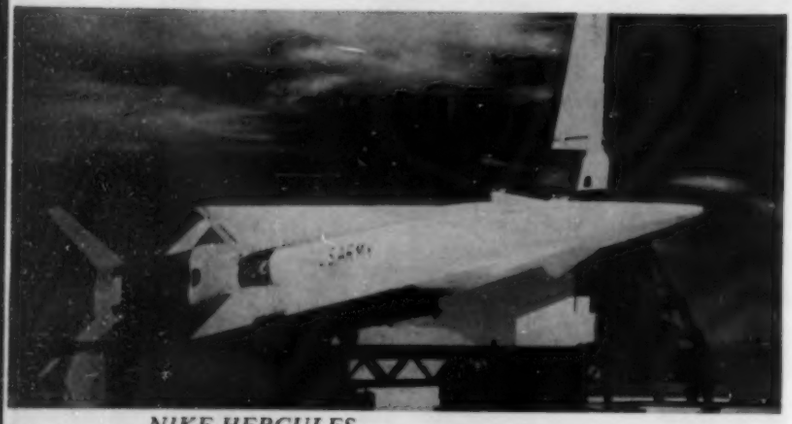


BOMARC A

BOMARC A'S AT McGUIRE AFB, N. J.



NIKE-AJAX



NIKE-HERCULES

TALOS

NIKE-AJAX (Army)

Military designation: SAM-A-7
Type: Surface-to-air
Status: Operational
Prime contractor: Western Electric Co.
Performance: Range—25 miles. Speed—Mach 2.5. Ceiling—60,000 ft.
Deployment: Location—United States, Western Europe, Far East. Initially operational—1953. Total battalions—about 40. Battalion strength—4 batteries. Battery strength—9 launchers. Total launchers—nearly 1500.
Frame: System contractor—Douglas. Length—31 ft. Diameter—12 in. Wingspan—52 in. Launch weight—2300 lbs. Material (major)—aluminum and steel.
Guidance: System contractor—Western Electric. Type—command.
Booster: System contractor—Thiokol. Propellant—solid.
Sustainer: System contractor—Thiokol. Propellant—liquid.
Payload: Warhead type—HE.
Ground support equipment: Launchers — Consolidated Western Steel. Transport vehicles—Fruehauf.
Remarks: Nike-Ajax is being replaced by the far more advanced Nike-Hercules.

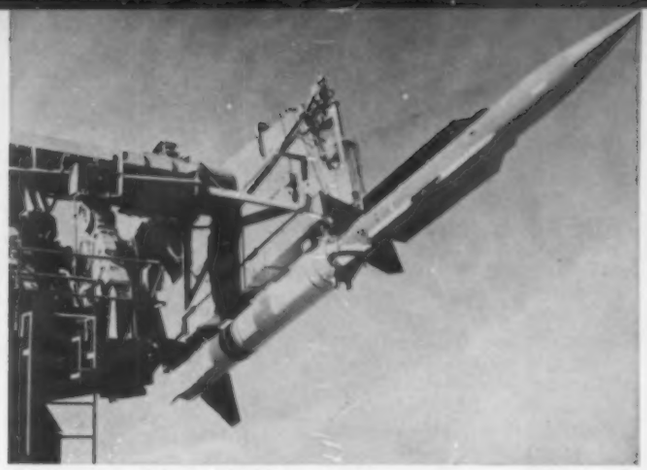
NIKE-HERCULES (Army)

Military designation: SAM-A-25
Type: Surface-to-air (anti-missile capability)
Status: Operational
Prime contractor: Western Electric Co.
Performance: Range—more than 75 n. miles. Speed—Mach 3 plus. Ceiling—more than 150,000 ft.
Deployment: Location—United States, Western Europe, Far East. Initially operational—mid-1958. Total battalions—about 20. Battalion strength—4 batteries. Battery strength—9 launchers. Total launchers—more than 700.
Frame: System contractor—Douglas. Length—39 ft. Diameter—31.5 in. Wingspan—90 in. Launch weight—10,000 lbs. Material (major)—aluminum and steel.
Guidance: System contractor—Western Electric. Type—command.
Booster: System contractor—Hercules Powder. Propellant—solid.
Sustainer: System contractor—Thiokol. Propellant—solid.
Payload: Warhead type—nuclear or HE.
Ground support equipment: Launchers — Consolidated Western Steel. Transport vehicles: Fruehauf.
Remarks: New General Electric radars give Nike-Hercules the capability of intercepting incoming tactical missiles. The Army plans to install improved system in Europe and other appropriate areas. The Army also is expected to build mobile Nike-Hercules anti-missile batteries for deployment in the field.

TALOS (Navy)

Military designation: SAM-N-6
Type: Surface-to-air and surface-to-surface (Seagoing)
Status: Operational
Prime contractor: Bendix Aviation Corp. System engineer—Vitro Corp.
Performance: Range—more than 65 n. miles. Speed—about Mach 2.5. Ceiling — extremely high altitude.
Deployment: Location—aboard the Missile Cruiser Galveston. To be deployed aboard at least six more cruisers including the nuclear-powered Cruiser Long Beach. Initially operational—1959.
Frame: System contractor—McDonnell. Length—about 30 ft. Diameter—about 30 in. Launch weight—7000 lbs. (booster alone weighs 4000 lbs.) Material (major)—steel
Guidance: System contractor—Bendix/Sperry. Type—beam riding.
Booster: System contractor—Allegany Ballistics Lab. Type—solid.
Payload: Warhead type—nuclear or HE.
Ground support equipment: Launchers—Naval Weapons Plant.
Remarks: Improvements in the Talos system have led to work on an anti-missile system called Typhon.

TERRIER



ADVANCED TERRIER

TERRIER (Navy)

Military designation: SAM-N-7
Type: Surface-to-air (seagoing)
Status: Operational
Prime contractor: Convair Division, General Dynamics Corp. System engineer—Vitro Corp.
Performance: Range—about 10 n. miles. Speed—supersonic. Ceiling—more than 50,000 ft.
Deployment: Location—aboard U.S. destroyers, frigates and cruisers. Also used in a mobile version by Marines. Initially operational—1956.
Frame: System contractor—Convair. Length—29 ft. (with 15 ft. booster). Diameter—12 in. Launch weight—2500 lbs.
Guidance: System contractor—Reeves/FTL. Sperry. Type—radar beam rider.
Booster: System contractor—Allegany Ballistics Lab. Propellant—solid.
Sustainer: System contractor—Allegany Ballistics Lab. Propellant—solid.
Payload: Warhead type—HE.
Remarks: Terrier is being replaced by the Convair Advanced Terrier. The Advanced Terrier's performance is about 100% greater than Terrier's. The new Frigate Dewey is the first ship to be armed with Advanced Terrier.

TARTAR

TARTAR (Navy)

Military designation: Mark 15
Type: Surface-to-air (seagoing)
Status: Operational
Prime contractor: Convair Division, General Dynamics Corp. System engineer—Vitro Corp.
Performance: Range—more than 10 n. miles. Speed—supersonic. Ceiling—high-altitude.
Deployment: Location—to be installed aboard 21 destroyers and three cruisers. Initially operational—1960.
Frame: System contractor—Convair. Length—15 ft. Diameter—12 in. Launch weight—about 1500 lbs.
Guidance: System contractor—Raytheon.
Booster: System contractor—Aerojet. Propellant—solid.
Payload: Warhead type—HE.
Ground support equipment: Launcher — Puget Sound Naval Shipyard. Handling—Washington Technological Associates/Naval Weapons Plant.

HAWK

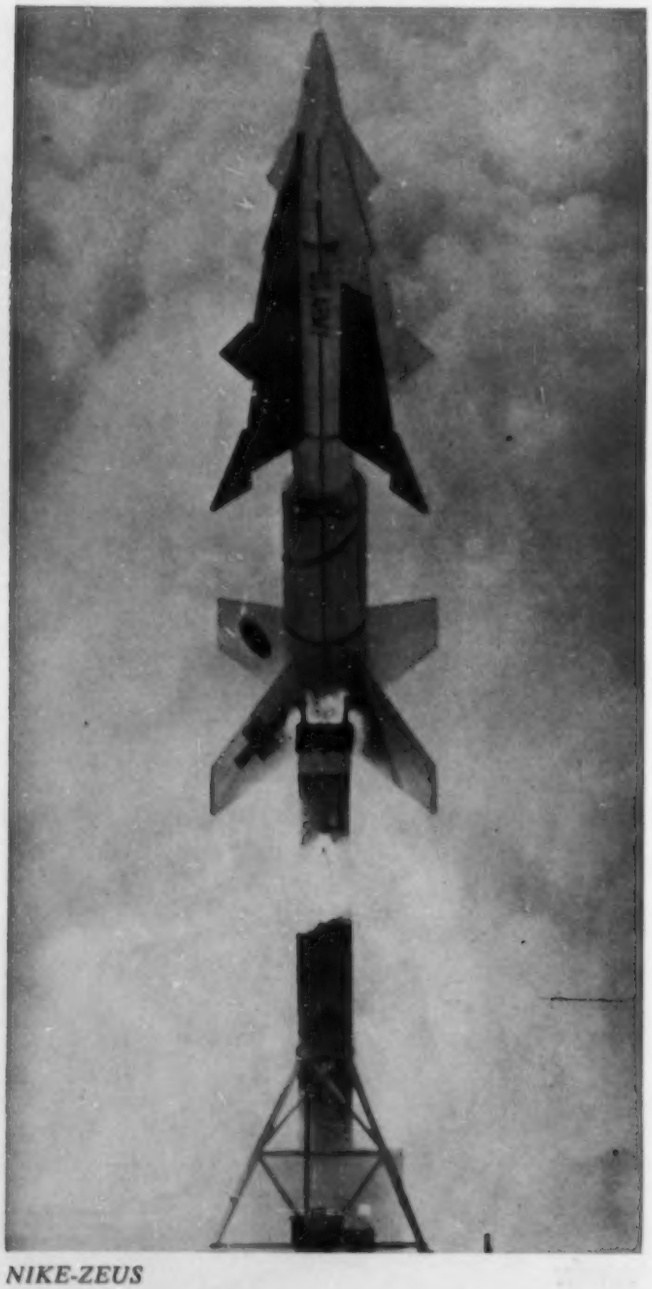
HAWK (Army)

Military designation: XM3E1
Type: Surface-to-air
Status: Operational
Prime contractor: Raytheon Co.
Performance: Range—about 22 n. miles. Speed—Mach 2 plus. Ceiling—tree-top level to about 40,000 ft. (Hawk is specifically designed for use against low-flying aircraft.)
Deployment: Location — U.S. troops training with Hawks in the United States. Initially operational—1959. Battalions—two. Battalion strength—3 to 5 batteries. Battery strength—6 to 12 launchers (3 missiles per launcher). Also to be used by Marine Corps and NATO allies.
Frame: System contractor — Raytheon/Northrop. Temco. Length—17 ft. Diameter—14 in. Wingspan—48 in. Launch weight—1275 lbs. Material (major) — aluminum and steel.
Guidance: System contractor—Raytheon. Type—semi-active radar homing.
Booster: System contractor—Aerojet. Propellant—solid.
Sustainer: System contractor—Aerojet. Propellant—solid.
Payload: Warhead type—HE.
Ground support equipment: Launcher—Northrop. Handling and service—Raytheon, Northrop, Food Machinery and RCA. Transport vehicles—Food Machinery.
Remarks: Although Hawk is not an anti-missile missile, it has successfully intercepted an Honest John in a test. Hawk is highly mobile.

REDEYE (Army)

Type: Surface-to-air (shoulder-launched)
Status: Nearly operational
Prime contractor: Convair Division, General Dynamics Corp.
Performance: Designed to intercept low-flying jet aircraft. One man can operate and carry.
Deployment: Location—to be deployed with Army and Marine combat troops. Initially operational—late 1960.
Frame: System contractor—Convair. Length—4 ft. Diameter—3 in. Launch weight—20 lbs.
Guidance: System contractor—Philco/Convair. Type—Infrared.
Booster: System contractor—Atlantic Research. Propellant—solid.
Payload: Warhead type—HE.
Remarks: Redeye is shipped, carried and launched from a disposable bazooka-shaped container.

REDEYE



NIKE-ZEUS

ANTI-MISSILE

NIKE-ZEUS (Army)

Type: Surface-to-air anti-ICBM and IRBM.
Status: R&D
Prime contractor: Western Electric Co.
Performance: Range—about 200 n. miles. Speed—est. Mach 4.
Deployment: Location — continental United States (particularly around soft SAC bases). Initially operational—about 1964. Total batteries—undetermined. Battery strength—about 50 launchers.
Frame: System contractor—Douglas. Length—about 65 ft. Diameter—about 5 ft.
Guidance: System contractor—Western Electric. Type—command.
Booster: System contractor—Thiokol. Propellant—solid.
Sustainer: System contractor—Grand Central. Propellant—solid.
Payload: Warhead type—nuclear.
Ground support equipment: Launcher—Douglas. Handling and service—Douglas.
Remarks: The future of the Nike-Zeus system is in doubt. The Eisenhower Administration refused to permit the Army to begin production thereby causing deployment to slip. However plans for flight-testing the missile in the Pacific in mid-1961 against live missiles were approved.

TYPHON (Navy)

Type: Surface-to-air (anti-missile missile)
Status: R&D
Prime contractor: Westinghouse Electric Corp./Applied Physics Lab
Performance: Designed to intercept both incoming tactical missiles and missiles launched from submerged submarines seconds after launching. Range—est. 100 n. miles. Speed—supersonic.
Deployment: Location—aboard cruisers, destroyers and possibly hydrofoil destroyers.
Payload: Warhead type—nuclear or HE.
Remarks: Two types are being developed—Long Range Typhon (formerly called Super Talos) and Medium Range Typhon (formerly called Super Tartar).

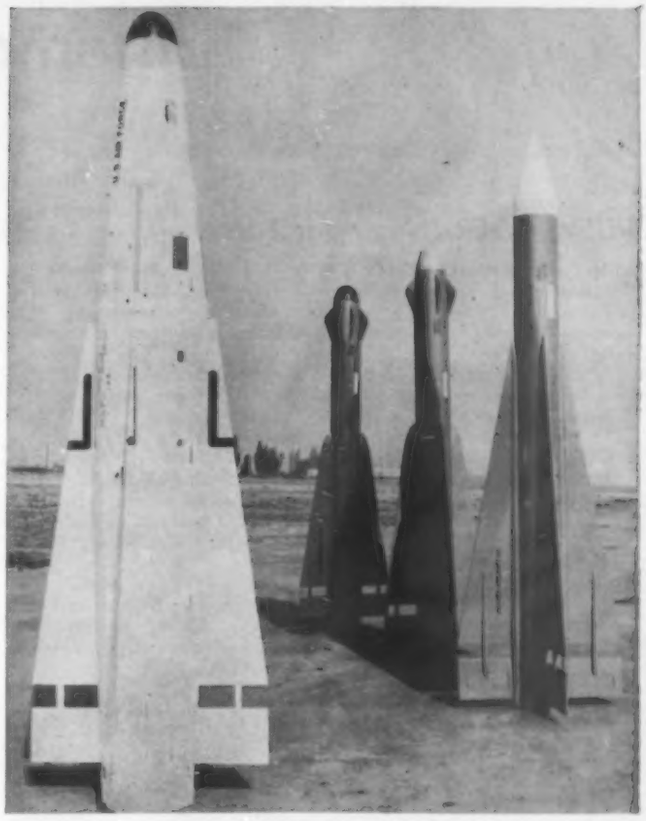
MAULER (Army)

Type: Surface-to-air (anti-missile missile)
Status: R&D
Prime contractor: Convair Division, General Dynamics Corp.
Performance: Designed to intercept incoming tactical missiles and jet aircraft.
Deployment: Location—to be put in hands of Army combat units in near forward positions.
Guidance: Type—radar.
Booster: Propellant—solid.
Remarks: Mauler will be launched from tracked vehicle manned by crew of only several men. System will be self-propelled and highly mobile and compact. Seagoing version has been proposed.

AIR-TO-AIR

FALCON (Air Force)

Military designation: GAR-1 through GAR-4, GAR-9 and GAR-11
Type: Air-to-air
Status: Operational (GAR-1 through GAR-4) and R&D (GAR-9 and GAR-11)
Prime contractor: Hughes Aircraft Co.
Performance: Range—about 5 n. miles. Speed—supersonic. (Greater ranges and speeds for GAR-3 and GAR-4, GAR-9 and GAR-11)
Deployment: Location—Air Defense Command aircraft (F-89, F-101, F-102 and F-106). Initially operational — 1957 (first versions).
Frame: System contractor—Hughes. Length—about 6.5-7 ft. (GAR-11 is more than 7 ft.). Diameter—6.4 in. GAR-11 is 7 ft. 11 in.) Wingspan—20 in. Launch weight—more than 120 lbs. (GAR-11 is more than 200 lbs.)
Guidance: System—contractor—Hughes. Type—(GAR-1D and GAR-3) radar homing; (GAR-2 and GAR-4) infrared.
Booster: System contractor—Thiokol. Propellant—solid.
Payload: Warhead type—(GAR-1 through GAR-4) HE; (GAR-11 and probably GAR-9) nuclear.
Remarks: GAR-3 and GAR-4 are known as Super Falcons. GAR-9 was originally designed for the now-cancelled F-108 Mach 3 interceptor.



FALCONS (FROM LEFT): GAR-11, GAR-1D, GAR-2A, GAR-3

GENIE (Air Force)

Military designation: MB-1
Type: Air-to-air
Status: Operational
Prime contractor: Douglas Aircraft Co.
Performance: Range—1.5 n. miles. Speed—supersonic.
Deployment: Location—aboard Air Defense Command aircraft (F-89's, F-101's, F-106's). Initially operational—about 1958.
Frame: System contractor—Douglas. Length—eight ft. Launch weight—nearly 1000 lbs.
Guidance: Type—free flight.
Booster: System contractor—Aerojet. Propellant—solid.
Payload: Warhead type—nuclear.
Ground support equipment: Launcher—Douglas. Handling and service—Douglas. Transport vehicles—Fruehauf.

GENIE

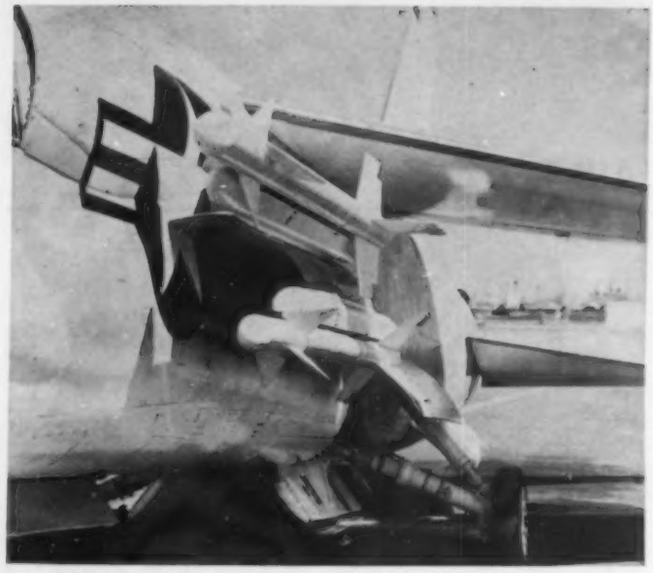
SPARROW III

SPARROW III (Navy)

Military designation: AAM-N-6A
Type: Air-to-air
Status: Operational
Prime contractor: Raytheon Co.
Performance: Range—more than 5 n. miles. Speed—more than Mach 2.
Deployment: Location—carrier-based U.S. Navy aircraft. Also with Marine units. Initially operational—August, 1958, replacing Sparrow I.
Frame: System contractor—Raytheon. Length—12 ft. Diameter—8 in. Launch weight—400 lbs. Material (major)—aluminum.
Guidance: System contractor—Raytheon. Type—radar homing.
Booster: System contractor—Aerojet. Propellant—solid (A new version of Sparrow with greater capability has Thiokol booster with packaged liquid propellant.) Thrust (solid)—7800 lbs.
Payload: Warhead type—HE.
Ground support equipment: Handling and service—Raytheon.
Remarks: Sparrow gave the Navy an all-weather missile when Sidewinder had only IR guidance.

SIDEWINDER (Navy-Air Force)

Military designation: AAM-N-7 (Navy) and GAR-8 (Air Force)
Type: Air-to-air
Status: Operational
Prime contractor: Philco Corp./ General Electric Co.
Performance: Range—about 2 n. miles. Speed—supersonic. Ceiling—more than 50,000 ft.
Deployment: Location—carried by carrier-based Naval aircraft and Air Defense Command aircraft. Also widely used by U.S. allies. Initially operational—mid-1956.
Frame: System contractor—Norris Thermador/Hunter-Douglas. Length—9 ft. Diameter—5 in. Launch weight—about 155 lbs. Material (major)—aluminum.
Guidance: System contractor—Philco/GE. Type—Infrared.
Booster: System contractor—Naval Propellant Plant. Propellant—solid.
Payload: Warhead type—HE.
Remarks: Philco is prime contractor for Sidewinder I-C, a second-generation missile with greater speed and range. I-C will have switchable IR and radar homing warheads. The Naval Ordnance Test Station at China Lake, Calif., developer of Sidewinder, also is developing I-C.



SIDEWINDER

EAGLE (Navy)

Military designation: XAAM-N-10
Type: Air-to-air
Status: R&D
Prime contractor: Bendix Corp.
Performance: Range—est. 100 n. miles. Speed—more than Mach 3.
Deployment: Location—to be launched from new low-speed, long-endurance plane called Missileer which is to be developed and deployed on carriers.
Frame: System contractor—Grumman. Length—est. 15 ft. Launch weight—about 2000 lbs.
Guidance: System contractor—Bendix. Type—radar homing.
Booster: System contractor—Aerojet. Type—solid.
Payload: Warhead type—nuclear or HE.
Remarks: Eagle introduces a new Navy concept of putting high performance into an air-launched missile that will be fired from a low-speed aircraft.

ZUNI (Navy)

Type: Air-to-surface
Status: Operational
Prime contractor: Naval Ordnance Test Station, China Lake
Performance: Range—about 5 n. miles. Speed—about 3000 ft./sec.
Deployment: Location—carrier-based aircraft. Initially operational—1957.
Frame: Length—110 in. Diameter—5 in. Launch weight—107 lbs.
Guidance: Type—free flight.
Booster: System contractor—Hunter-Douglas. Type—solid. Thrust—7000 lbs.
Payload: Warhead type—HE (also variety of other conventional warheads including flares.)
Remarks: The four-rocket launchers, which also are used for transporting and storing Zunis, can be jettisoned from plane after rockets are launched. AD-type Naval aircraft can carry up to 48 Zunis.

ZUNI

Anti-submarine

The decade of the 1960's is seeing the missile come into its own as a weapon for attacking submarines.

ASROC—the greatest step forward in the development of an ASW missile in a decade—is already operational. SUBROC is expected to be operational in less than a year.

Meantime, improvements in both systems are under consideration.

The stumbling block continues to be detection. Any improvements in detection can be quickly followed by improvements in the missiles themselves.

WEAPON ALFA (Navy)

Type: ASW surface-to-underwater
Status: Operational
Prime contractor: Navy
Performance: Range—about 900 yards
Deployment: Location—aboard U.S. destroyers and cruisers. Initially operational—1952
Frame: System contractor—Avco. Length—8.5 ft. Diameter—12.75 in. Launch weight—500 lbs.
Guidance: Type—free flight
Booster: Propellant—solid
Payload: Warhead type—HE depth charge
Remarks: Alfa is launched from guns mounted in turrets

WEAPON ALFA

ASTOR (Navy)

Type: ASW rocket torpedo
Status: R&D
Prime contractor: Westinghouse Electric Corp.
Performance: Range—reported to be about 11 n. miles
Deployment: Location—aboard U.S. fleet submarines
Frame: System contractor—Westinghouse. Length—nearly 20 ft. Launch weight—more than 2000 lbs.
Guidance: Type—reported to be partly wire.
Powerplant: Type—reported to be electric and rocket-boosted. Propellant—solid
Payload: Warhead type—nuclear or HE.

ASTOR

ASROC (Navy)

Type: ASW surface-to-underwater
Status: Operational
Prime contractor: Minneapolis-Honeywell Regulator Co.
Performance: Range—about 8 n. miles. Speed—nearly Mach 1.
Deployment: Location—Destroyer Leader Norfolk and Destroyer Peary. The Navy plans to install ASROC aboard a total of 150 destroyers and cruisers within the next few years. Initially operational: 1960. Launcher capacity—eight. (Some ships will carry reloads)
Frame: System contractor—Minneapolis-Honeywell. Length—15 ft. Torpedo-warhead length—100 in. Missile diameter—1 ft. Overall diameter—2.5 ft. Launch weight—about 1000 lbs.
Fire control: System contractor—Librascope. Type—digital computer operated.
Sonar detection: System contractor—Sangamo Electric. Type—SQS-23.
Booster: Propellant—solid.
Payload: Warhead—General Electric Mark 44 acoustic homing torpedo or depth charge. Type—HE (depth charge can be nuclear)
Ground support equipment: Launcher—Universal Match

ASROC

SUBROC (Navy)

Type: ASW underwater-to-underwater
Status: R&D
Prime contractor: Goodyear Aircraft Corp.
Performance: Range—about 25 n. miles.
Deployment: Location—aboard nuclear-powered attack submarines. Scheduled to be installed first aboard the Thresher. Initially operational—1961.
Frame: System contractor—Goodyear.
Guidance: System contractor—Kearfott.
Fire control: System contractor—Librascope.
Booster: System contractor—Thiokol. Type—solid.
Payload: Warhead type—nuclear or HE.
Remarks: Subroc will be launched underwater from a conventional submarine tube, leave the water, travel through the air and re-enter the water to strike an enemy submarine

Directory of Rocket Engines

The biggest engines in America's inventory today still are propelled by the liquid combination of LOX and RP-1.

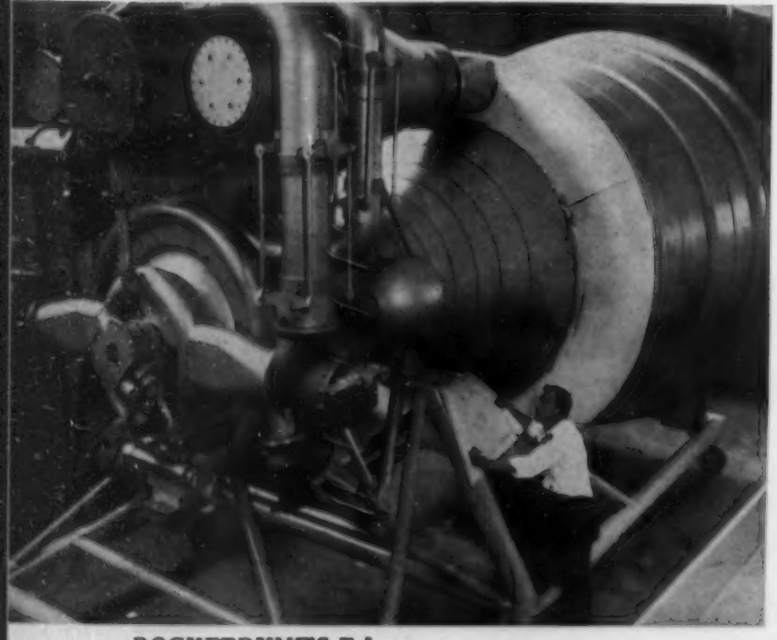
The Rocketdyne 150,000-lb.-thrust engine is the basic U.S. power plant for large liquid rockets. Developed for the Jupiter IRBM, it has been adapted for the Thor IRBM, used in pairs for the Atlas ICBM and modified for clustering into the Saturn booster. The same combination propels the F-1, the largest single engine under development, and the booster powerplant of the Titan ICBM.

However, current propulsion trends are moving toward the high-energy LOX-liquid hydrogen system, storable propellants in liquids and increased use of solids where instant readiness, mobility and low price are major factors.

LIQUID ENGINES

NOVA ENGINE (NASA)

Manufacturer: Rocketdyne
Manufacturer's number: F-1
Propellants: LOX, kerosene
Nozzle config. & exp. ratio: Modified bell, regen. cooled, more than 12:1
Nozzle material: Unsettled
Length: About 20 ft.
Width (maximum): About 12 ft.
Weight: About 18,000 lbs.
Start system: Solid propellant
Ignition: Pyrophoric, tri-ethyl aluminum
Propellant supply: Turbopumped
Average thrust: 1,500,000 lbs.
Specific impulse, sea level: about 260 sec.; average during flight: about 290 sec.
Burning time: according to tank capacity
Status: R&D. Thrust chamber test this summer; first engine test next summer; pre-flight rating test complete by summer of 1963. Cluster of several F-1's—or a single F-1 and several H-1's—will be the booster of the Nova vehicle.



ROCKETDYNE'S F-1

SATURN BOOSTER ENGINE (NASA)

Manufacturer: Rocketdyne
Manufacturer's number: H-1
Propellants: LOX, kerosene
Nozzle config. & area ratio: Bell, regen. cooled, 8:1
Nozzle material: Nickel
Length: About 8 ft.
Width (maximum): 60 in.
Engine weight: About 1400 lbs.
Start system: Solid propellant
Ignition: Pyrophoric; tri-ethyl aluminum
Propellant supply: Turbopumped
Average thrust (sea level): 165,000 lbs; later to be 188,000 lbs.
Specific impulse (sea level): 255 sec.
Burning time: According to tank capacity
Status: R&D. Earlier versions operational in Jupiter, Thor, Atlas

ATLAS BOOSTER (Air Force)

Manufacturer: Rocketdyne
Manufacturer's numbers: MA2, MA3
Propellants: LOX, kerosene
Nozzle config. & area ratio: Bell, regen. cooled, 8:1
Nozzle material: Nickel
Length: About 8 ft.
Width (maximum, one engine): 60 in.
Weight (one engine): 1418 lbs.
Start system: MA2—LOX-kerosene gas gen.; MA3—solid propellant
Ignition: MA2 — pyrotechnic; MA3—pyrophoric, tri-ethyl aluminum
Average thrust: MA2—300,000 lbs.; MA3—330,000 lbs.
Number of engines: 2 with common pumpage
Propellant consumption (total): MA2—1240 lb./sec.; MA3—classified.
Burning time: 2 min.
Status: MA2 operational. MA3—R&D.

TITAN BOOSTER (Air Force)

Manufacturer: Aerojet-General
Military numbers: LR-87-AJ-3 and -5
Propellants: -3—LOX, kerosene; -5—nitrogen tetroxide and Aerozene-50 (50-50 mix of UDMH and hydrazine)
Nozzle config. & area ratio: Bell, regen. cooled; 8:1
Nozzle material: Stainless steel
Length: About 10 ft.
Width (maximum): About 9 ft.
Engine weight: About 3700 lbs.
Start system: -3—ground-supplied and bootstrap; -5—self-contained
Ignition: -3—pyrotechnic; -5—hypergolic
Propellant supply: Turbopumped
Number of engines: 2 fed by common tankage
Average thrust (sea level): -3—300,000 lbs.; 5—more than 400,000
Burning time: 120 sec.
Status: -3 has completed qualification tests; -5 is to complete qualification in about two years.

SATURN MIDSTAGE ENGINE (NASA)

Manufacturer: Rocketdyne
Manufacturer's number: J-2
Propellants: LOX, liquid hydrogen
Nozzle config. & area ratio: Bell, regen. cooled; over 30:1
Engine weight: About 2500 lbs.
Start system: LOX-hydrogen gas generator
Average thrust: 200,000 lbs.
Specific impulse (vacuum): More than 420 sec.
Burning time: More than 100 sec.
Status: NASA chose Rocketdyne in June, 1960, to conduct a three-year program leading to preflight rating test. Many engine details unsettled.

& Motors

ATLAS SUSTAINER (Air Force)

Manufacturer: Rocketdyne
Manufacturer's number: S-4 (part of propulsion systems MA2 and MA3)
Propellants: LOX, kerosene
Nozzle config. & area ratio: Bell, regen. cooled, 25:1
Nozzle material: Nickel
Length: About 8 ft.
Width (maximum): About 60 in.
Engine weight: 984 lbs.
Start system: Same as booster
Ignition: Same as booster
Thrust: 57,000 sea level, 80,000 vacuum
Burning time: About 270 sec.
Status: Operational in MA2; R&D in MA3.

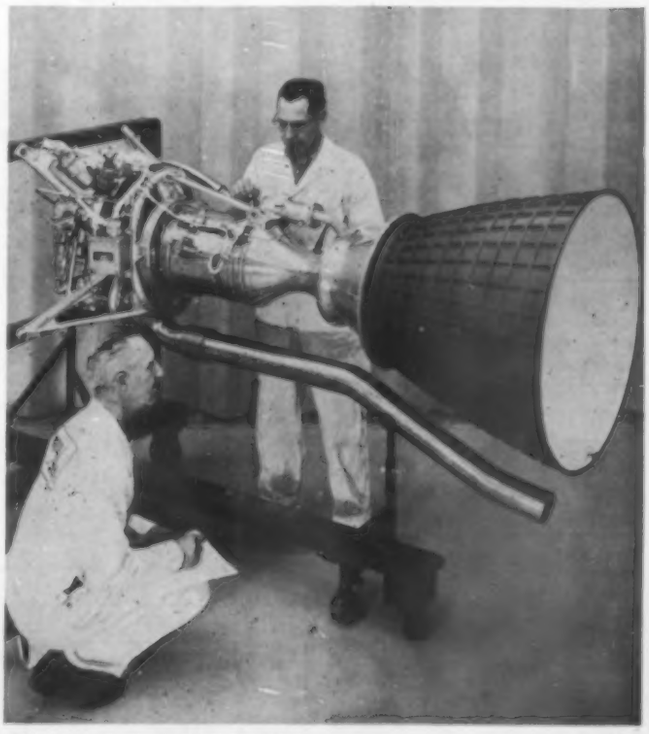
ATLAS SUSTAINER

TITAN SUSTAINER (Air Force)

Manufacturer: Aerojet-General
Military numbers: LR-91-AJ-3 and -5
Propellants: -3—LOX, kerosene; -5—nitrogen tetroxide and Aerozene-50
Nozzle config. & area ratio: Bell, partly regeneratively cooled, 25:1
Nozzle material: Stainless steel
Length: About 7 ft.
Width (maximum): About 4 ft.
Engine weight: About 1300 lbs.
Start system: Self-contained
Ignition: -3—pyrotechnic; -5—hypergolic
Propellant supply: Turbopumped
Average thrust (vacuum), lbs.: -3—80,000; -5—slightly higher
Burning time, sec: 150
Status: -3 is completing qualification tests; -5 is to complete qual. tests in about two years.

CENTAUR ENGINE (NASA)

Manufacturer: Pratt & Whitney
Military number: LR-115
Propellants: LOX, liquid hydrogen
Nozzle config. & area ratio: Bell, regen. cooled, over 30:1
Nozzle material: Stainless steel
Start system: Bootstrap hydrogen expansion pump
Ignition: Electric
Average thrust: 15,000 lbs.; almost 20,000 lbs. in later version
Specific impulse: 30% higher than LOX-kerosene; number not given
Burning time: About 5 min. in Centaur
Status: R&D; to be flown in Centaur in 1961; to be used in Saturn upper stages beginning in 1963.



BELL'S AGENA ENGINE

AGENA ENGINE (Air Force and NASA)

Manufacturer: Bell Aircraft
Military numbers: XLR-81-BA-5, -7 and -9
Propellants: IRFNA, UDMH
Start system: -5 single start, -7 and -9 restartable in space
Ignition: Hypergolic
Propellant feed: Turbopumped
Average thrust: 15,500 except 16,000 in -9
Burning time: -5—about 120 sec.; -7 and -9—about 240 sec.
Propellant weight: -5—8500 lbs.; -7 and -9—17,000 lbs.
Status: -5 operational in Agena A; -7 coming into operation in early Agena B; -9 in production for later Agena B.

VANGUARD-VEGA ENGINE (NASA)

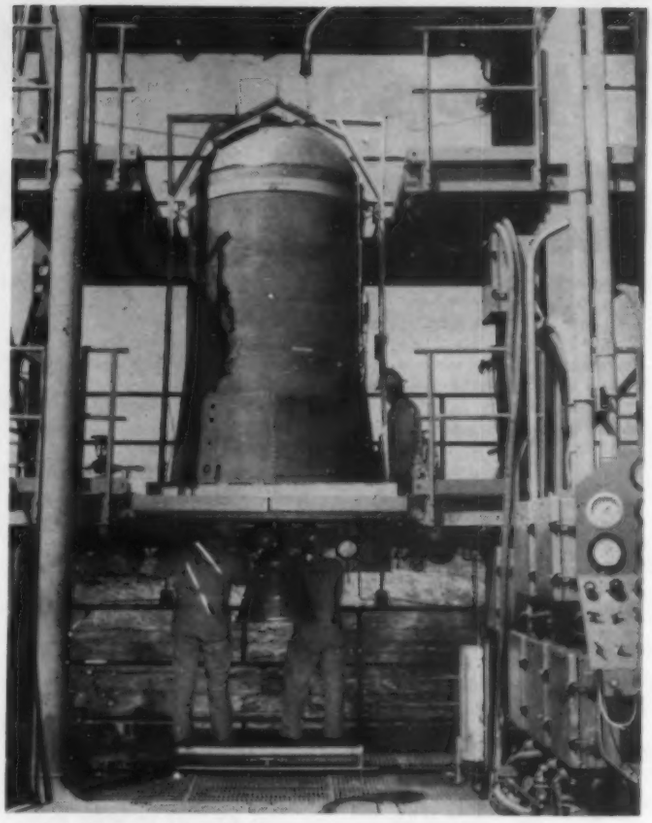
Manufacturer: General Electric
Military numbers: X405; X405H
Propellants: LOX, kerosene
Nozzle config. & area ratio: 405—single-CD single-pass double shell, 5.5:1; 405H—tube bundle, 25:1
Nozzle material: Steel
Length: 405—80 in.; 405H—65 in.
Width: 405—40 in.; 405H—27.5 in.
Weight: 405—421 lbs.; 405H—458 lbs.
Propellant supply: Turbopumped
Ignition: 405 — pyrotechnic; 405H—pyrophoric tri-ethyl aluminum
Thrust, sea level: 405—28,000 lbs.; 405H—35,000 lbs.
Burning time: 405—150 sec.; 405H—250 sec.
Status: X405, the booster engine on Vanguard, has now phased out. X405H was developed for use as an upper stage, atop an Atlas, for the Vega vehicle. Although the Vega vehicle was cancelled, X405H development was continued through preflight rating test.

VARIABLE THRUST ENGINE (Air Force)

Manufacturer: Aerojet-General
Military number: LR-113-AJ-1
Propellants: Nitrogen Tetroxide, UDMH
Nozzle config. & area ratio: Conical, film-cooled, about 6:1
Nozzle material: Steel
Length: About 5 ft.
Width: About 2½ ft.
Weight (maximum): About 1000 lbs.
Ignition: Hypergolic
Propellant supply: Pressure-fed
Thrust (sea level): 50,000-150,000 lbs.
Burning time (full thrust): About 10 sec.
Status: Qualified for sled use.

GAMMA ENGINE (British)

Manufacturer: Bristol Siddeley
Manufacturer's number: A. S. Gamma Mk. 201
Propellants: 85-7% hydrogen peroxide, kerosene
Nozzle configuration: Bell, regen. cooled
Length: 90 in.
Width (maximum): 36 in.
Engine weight: 700 lbs.
Ignition: Catalytic decomposition & hypergolic
Propellant feed: Turbopumped
Number of chambers: 4
Total thrust: Sea level—16,000-16,800; Vacuum—19,000
Status: Operational in the Black Knight Re-entry research vehicle.



ABLESTAR ENGINE

NUCLEAR

ROVER NUCLEAR ENGINE (AEC and NASA)

Manufacturer: Los Alamos Scientific Lab.
Propellant: Liquid hydrogen
Nozzle config.: Bell, regen. cooled
Total weight: 39,000 lbs.
Reactor power: 1,000 megawatts thermal
Thrust (sea level): 52,000 lbs.
Propulsion time: More than 5 minutes.
Status: R&D. Tests of non-flying Kiwi engines began last summer. NASA says will be ready for orbital flight test by 1965. AEC says system could be proved sooner with ground-launched test.

ABLE SERIES ENGINES

The Aerojet-General Able series of engines originated with the second stage of Vanguard and was adapted for the Thor-Able. The Able still has two flights with the Atlas-Able scheduled this year before it phases out in favor of Delta in NASA vehicles and Ablestar in some military satellites.

ENGINE	AJ10-101 (ABLE)	AJ10-110 (DELTA)	AJ10-104 (ABLESTAR)
Propellants	IRFNA, UDMH	WIFNA, UDMH	IRFNA, UDMH
Nozzle configuration & area ratio	Bell, tube bundle, 20:1	Bell, tube bundle, 20:1	Bell, tube bundle to 20:1; Uncooled extension to 40:1
Nozzle material	Aluminum	Stainless steel	Aluminum to 20:1; titanium extension
Length, in. (including tanks)	About 190	About 190	About 207
Width (maximum), in.	About 32	About 32	About 55
Start system	Self-contained, wet	Self-contained, wet	Wet or dry, restartable
Ignition	Hypergolic	Hypergolic	Hypergolic
Propellant supply	Helium pressure feed	Helium pressure feed	Helium pressure feed
Average thrust (vac.) lbs.	About 7800	About 7800	About 8000
Burning time, sec.	About 120	About 120	About 300

SOLID MOTORS

Solid propulsion has made large strides in the last year, particularly in the development of rocket hardware. The Polaris Fleet Ballistic Missile and the Scout satellite launcher are nearly operational and the Minuteman ICBM has progressed to the point where even larger solid motors are being considered.

ALGOL (NASA)

Manufacturer: Aerojet-General
Propellant: Polyurethane composite
Nozzle config. & exp. ratio: Cone, 4.7:1
Nozzle material: Steel
Length: 358 in.
Width (maximum): 40 in.
Weight (maximum): 22,640 lbs.
Weight unloaded: 3360 lbs.
Ignition: Squib
Average thrust (sea level): 104,500 lbs.
Burning time (web): 36 sec.
Total impulse (integrated, sea level to altitude): 4,080,000 lb.-sec.
Case material: Steel
Status: An early Polaris test vehicle, Algol was adapted for use as Scout booster. Engine development is complete.

CASTOR MOTOR (NASA)

Manufacturer: Thiokol
Propellant: Polybutadiene acrylic acid composite
Nozzle config. & exp. ratio: Cone, 16:1
Nozzle material: Steel
Length: 244 in.
Width: 31 in.
Total weight: 8870 lbs.
Weight unloaded: 1430 lbs.
Ignition: Squib
Total impulse (vac.): 1,940,000 lb.-sec.
Burning time (web): 27 sec.
Average thrust: Vacuum—63,050 lbs.; sea level—55,000 lbs.
Case material: Steel
Status: Operational. Castor, a modification of the motor in the Sergeant missile, is used as second stage of Scout and as a component in Little Joe and several sounding-type vehicles.

ANTARES MOTOR (NASA)

Manufacturer: Hercules-ABL
Military number: X254
Nozzle config. & area ratio: Cone, 25:1
Propellant: Double-base
Length: 115 in.
Width (maximum): 30 in.
Weight (maximum): 2300 lbs.
Weight unloaded: 180 lbs.
Ignition: Squib
Average thrust (web, vacuum): 14,500 lbs.
Burning time (web): 37 sec.
Total impulse: 534,000 lb.-sec.
Specific impulse (vacuum): 256 sec.
Case material: Fiber glass and resin
Status: Developed specially for use as Scout third stage; development complete.

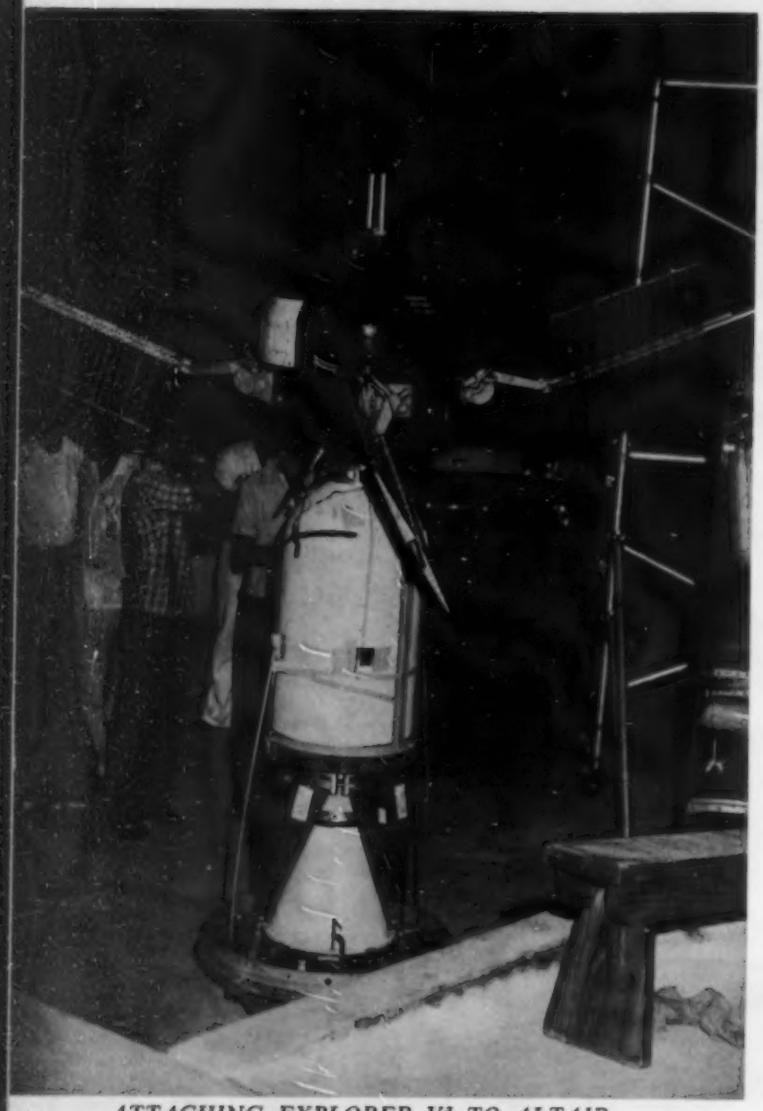
NIKE (Army)

Manufacturer: Hercules-ABL
Propellant: Double-base
Length: 150 in.
Diameter: 16 in.
Total weight: 1170 lbs.
Ignition: Squib
Average thrust: 50,000 lbs.
Case material: Steel
Status: Developed originally for the Nike-Ajax, this rocket is used in a cluster of four to boost Nike-Hercules. It is also widely used in sounding rockets and for sled propulsion.

LANCE MOTOR

Manufacturer: Grand Central
Manufacturer's number: GCR-S-394A
Propellant: Polysulfide composite
Nozzle config.: Straight
Nozzle material: Steel, graphite
Length: 185 in.
Diameter: 15.1 in.
Total weight: 1682 lbs.
Weight unloaded: 490 lbs.
Ignition: Pyrotechnic
Total impulse (sea level, (70°F): 258,000 lb.-sec.
Average thrust (web, sea level): 38,800 lbs.
Burning time: Web—6.65 sec.; total—8 sec.
Case material: Steel, 150,000 psi min. yield
Grain design: 5 pt. star burning
Status: In production.

AEROJET'S ALGOL



ATTACHING EXPLORER VI TO ALTAIR

ROCKETDYNE'S MEGABOOM

ALTAIR MOTOR (Navy and NASA)

Manufacturer: Hercules-ABL
Military number: X248
Propellant: Double-base
Nozzle config. & exp. ratio: Cone, 25:1
Nozzle material: Plastic
Length: 58 in.
Width (maximum): 18 in.
Weight (maximum): 514 lbs.
Weight unloaded: 52 lbs.
Ignition: Squib
Average thrust (web, vacuum): 3060 lbs.
Burning time (web): 38 sec.
Total impulse (vacuum): 116,500 lb.-sec.
Specific impulse (vacuum): 256 sec.
Case material: Fiber glass and resin
Status: Operational

METEOR MOTOR (NASA)

Manufacturer: Grand Central
Manufacturer's number: GCR-350
Propellant: Polysulfide composite
Nozzle config.: Straight DeLaval
Nozzle material: Steel, graphite
Length: 57.4 in.
Diameter: 18 in.
Total weight: 431 lbs.
Weight unloaded: 49.5 lbs.
Ignition: Gas generator
Total impulse (vacuum, 60°F): 90,800 lb.-sec.
Average thrust (web, vacuum): 2776 lbs.
Burning time: Web—28 sec.; total—37 sec.
Case material: Stainless steel, 135,000 psi min. yield
Grain design: 5 pt. star burning
Status: Used in early versions of Vanguard

RECRUIT MOTOR (NASA)

Manufacturer: Thiokol
Propellant: Polysulfide composite
Nozzle material: Steel
Length: 107 in.
Diameter: 9¼ in.
Total weight: 350 lbs.
Ignition: Squib
Burning time: 1.5 sec.
Average thrust: About 35,000 lbs.
Case material: Steel
Status: Operational; developed for use in X-17 research vehicle, Recruit has been used widely in sounding and test vehicles.

ASP MOTOR

Manufacturer: Cooper Development
Manufacturer's number: RM 1100
Propellant: Polysulfide composite
Nozzle config. & exp. ratio: Cone, 6.41:1
Nozzle material: Steel, graphite
Length: 106.9 in.
Diameter: 6.5 in.
Total weight: 192 lbs.
Weight unloaded: 42 lbs.
Ignition: Jellyroll
Average thrust (sea level, 80°F): 5982 lbs.
Burning time: Web—4.4 sec.; total—5.9 sec.
Total impulse (sea level): 31,706 lb.-sec.
Specific impulse: 215 sec.
Case material: Steel, proof to 1900 psia
Grain design: Tapered internal cylinder
Status: Operational

CAJUN (NASA)

Manufacturer: Thiokol
Propellant: Polysulfide composite
Nozzle configuration: Varies with mission
Nozzle material: Aluminum, graphite
Length: Mod I—108 in.; Mod II—107 in.; Mod III—104 in.
Width: 6¾ in.
Weight (maximum): Mod I—172 lbs.; Mod. II—171 lbs.; Mod III—166 lbs.
Ignition: Squib
Average thrust: 8100 lbs.
Burning time: 2.8 sec.
Case material: Aluminum
Grain design: Internal star
Status: Operational. Mod I used for high-altitude research, beginning with the International Geophysical Year; Mod II for rocket sled propulsion; Mod III in target missile systems.

SALUKI (British)

Manufacturer: Imperial Chemical
Length: Body—126.9 in.; overall—150.9 in.
Diameter: 24 in.
Case material: Steel
Status: Under development for the Ministry of Aviation. Saluki is apparently the largest British solid motor. Other details are unavailable.

RAVEN MOTOR (British)

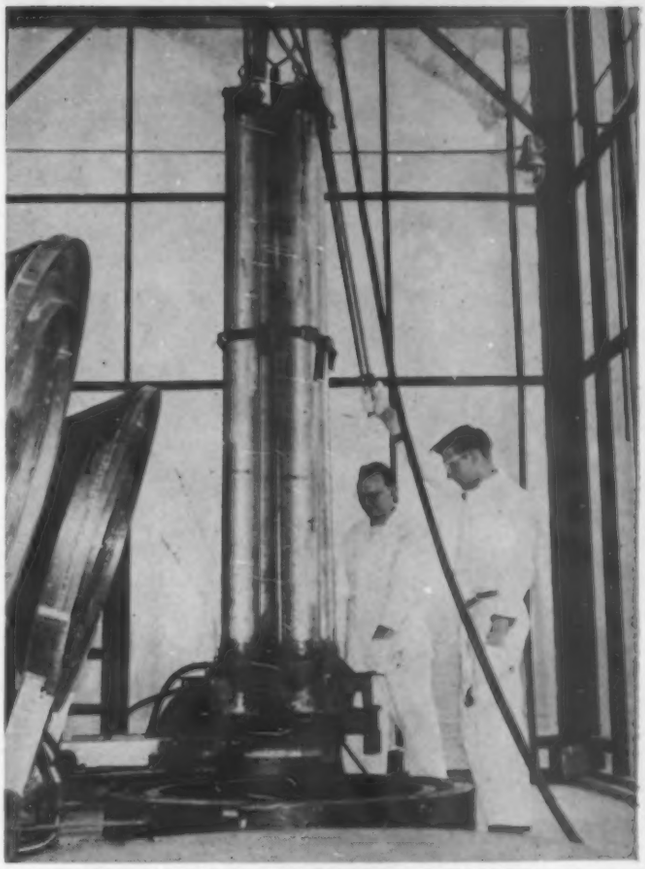
Manufacturer: Wescott R. P. E.
Propellant: Case-bondable composite
Length: 184 in.
Diameter: 17.4 in.
Total weight: 2200 lbs.
Weight unloaded: 400 lbs.
Average thrust: 12,000 lbs.
Burning time: 30 sec.
Specific impulse: 177 sec.
Case material: Steel
Status: Operational in Skylark sounding rocket.

BULLDOG MOTOR (British)

Manufacturer: Imperial Chemical
Nozzle material: Steel
Length: High-thrust model—127.6 in.; Low-thrust model—125.9 in.
Diameter: 17.5 in.
Ignition: Electrical
Average thrust: High model—46,700 lbs.; Low model—25,500 lbs.
Burning time: High thrust—2.5 sec. Low thrust—6.9 sec.
Case material: Steel
Status: R&D for the Ministry of Aviation

CUCKOO MOTOR (British)

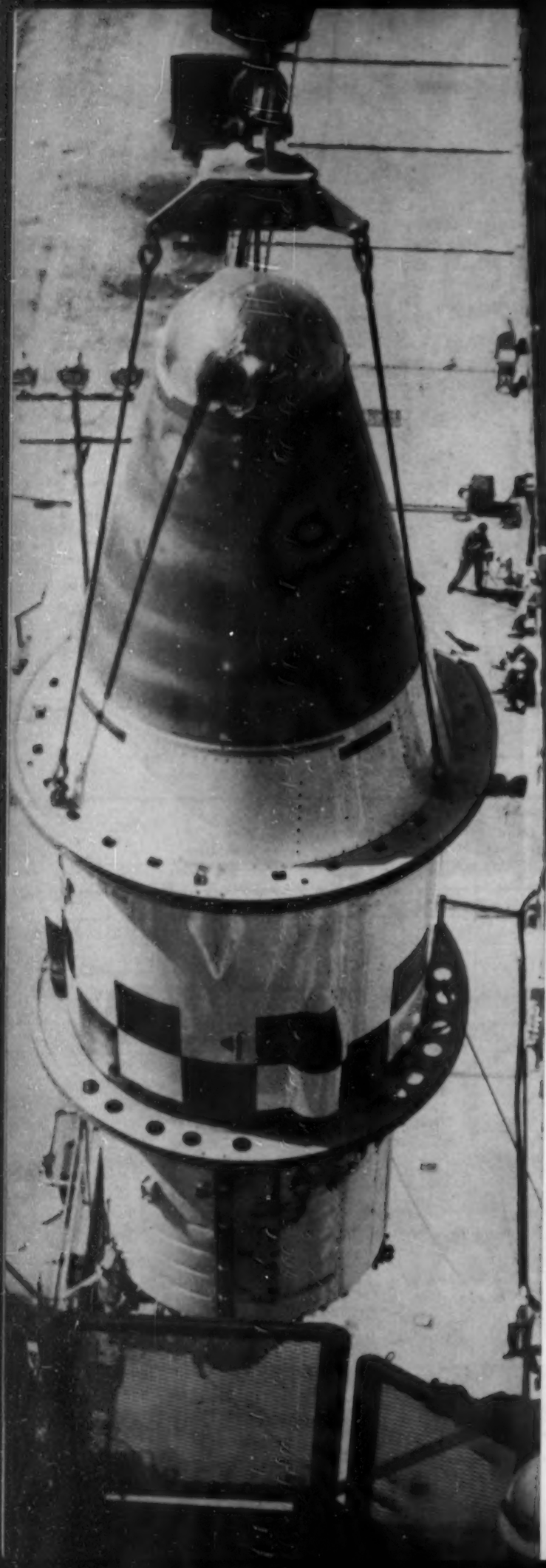
Manufacturer: Westcott R. P. E.
Propellant: Case-bondable composite
Burning time: About 4 sec.
Total impulse: 81,000 lb.-sec.
Status: Becoming operational as booster for Raven in Skylark sounding rocket.



THIOKOL APACHE MOTORS ABOVE CURING PIT

SOME OTHER SOLID MOTORS

Name	Manufacturer	Propellant	Total Wt. (lbs.)	Average Thrust (lbs.)	Burning Time (sec.)	Application
MEGABOOM	Rocketdyne	Butyl rubber	9460	100,000	10	Sled
APACHE	Thiokol	Polysulfide	223	N.A.	N.A.	Sounding (lifts 35 lbs. to 40 miles)
RECRUIT	Thiokol	Polysulfide		35,000	1.5	Sounding
JAVELIN	Grand Cent.	Polysulfide	351.1	18,000	3.2	Sled, missile
SABER	Grand Cent.	Nitrile	213	10,000	3.3	Sled, drone, sounding
ARCON	Atlantic Res.	Polyvin. Chlor.	213.1	945	33.0	Sounding
VIPER	Grand Cent.	Polysulfide	190.4	5070-7700	4.25-6	Sled, sounding
SWORD	Grand Cent.	Polysulfide	95.1	3020	4.75	TITAN separation
ARCAS	Atlantic Res.	Polyvin. Chlor.	64.5	350	28.4	Sounding
DART	Grand Cent.	Butyl rubber	42.0	100	44	Dual-range thrust; Start 640 lbs. 1.8 sec.
SKYDART	Grand Cent.	Butyl rubber	46.0	116	37	Dual-range thrust; Start 620 lbs. 1.9 sec.
ARROW	Grand Cent.	Polysulfide	17.8-24.4	1790-2400	1.1-2.1	Sled, drone, sounding
MARC 8	Atlantic Res.	Polyvin. Chlor.	17.4-17.7	860	1.48	THOR retro, MERCURY escape
TE-316	Thiokol	Polysulfide	N.A.	1000	N.A.	MERCURY orbital brake
MARC 7	Atlantic Res.	Polyvin. Chlor.	4.8-5	410	1.1	ATLAS retro, MERCURY separation, EXPLORER VI orbital control
MARC 6	Atlantic Res.	Polyvin. Chlor.	3.35-3.55	214	1.0	THOR-ABLE vernier, satellite orbital control
MARC 5	Atlantic Res.	Polyvin. Chlor.	1.3-1.37	121	0.51	Spin stabilization, de-spin ATLAS-ABLE, EXPLORER, DISCOVERER
MARC 4	Atlantic Res.	Polyvin. Chlor.	.62-.64	46	1.05	Retro, spin VANGUARD, PIONEER, SCOUT, DELTA, DISCOVERER
FANG	Grand Cent.	Polysulfide	1.0	37	1.3	Nose cone spin, component stabilizer
MARC 3	Atlantic Res.	Polyvin. Chlor.	.085	5	0.3	TIROS spin stabilization



Space Vehicles

America's two major bids for a large role in space exploration are NASA's huge Saturn booster and the Air Force's Dyna-Soar space bomber.

But Saturn's first operational flight is still several years away at best; Dyna-Soar on its present schedule several times that.

Meantime, Russia and the United States continue to race to put the first man in orbit with the odds of success still heavily in favor of Russia.

In the field of military space satellites, the United States appears to be doing better. But some congressmen have charged that these programs, too, are not being pushed to the limit.

Lack of financial support continues to be the problem.

SATELLITES/SPACECRAFT

MIDAS (Air Force)

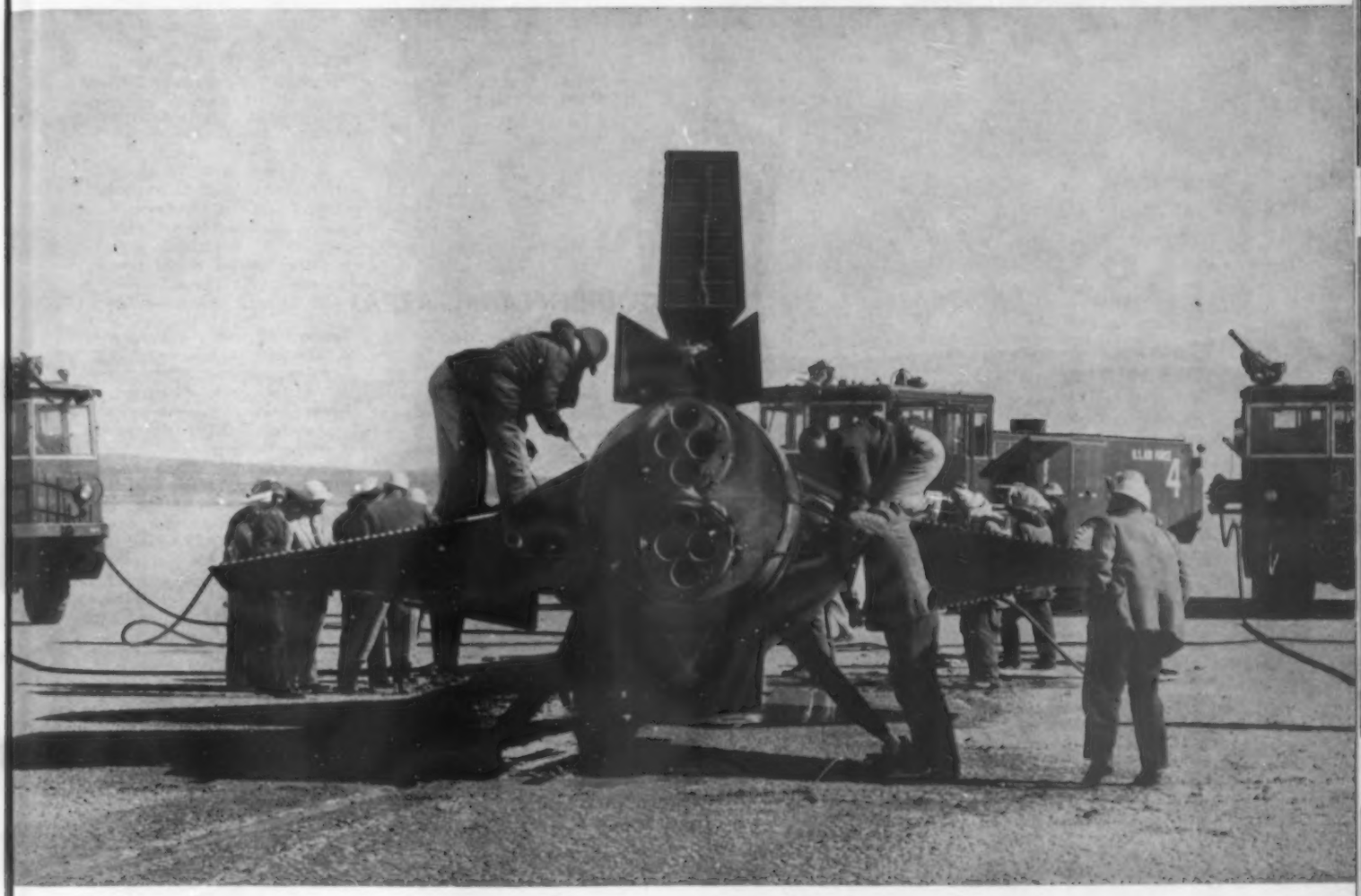
Type: Early-warning satellite
Status: R&D
Prime contractor: Lockheed Aircraft Co.
Performance: Orbit—about 300 n. miles; polar.
Deployment: Initially operational—about 1963. Number satellites—more than a half-dozen.
Frame: System contractor—Lockheed. Height—22 ft. Diameter—5 ft. Weight—about 5000 lbs. (operational weight about 3000 lbs.)
Instrumentation: Type—IR scanner designed to detect exhaust flames of a long-range ballistic missile seconds after it is launched; data link telemetry; tape-fed programer
Booster: System contractor: Convair. Type—Atlas ICBM. Propellant—liquid.
Sustainer: System contractor—Lockheed. Type—Agena. Propellant—liquid.
Remarks: Midas II successfully launched May 24, 1960, into 300/319 mile orbit, but an equipment failure made testing of the IR scanner impossible. The launching of Midas I failed because of a breakdown in the second stage. Estimated life of Midas II—40 months.

DYNA-SOAR (Air Force)

Type: Boost-glide space bomber
Status: R&D
Prime contractor: Boeing Airplane Co.
Performance: Range—global. Speed—ultimately orbital.
Deployment: Initially operational—late 1960's.
Frame: System contractor—Boeing. Configuration—glider.
Booster: System contractor—Martin. Type—modified Titan ICBM. Propellant—liquid.
Remarks: The program is divided into phases beginning with the dropping and launching of unmanned gliders. The first manned gliders will be boosted down the Atlantic Missile Range.

LEFT: MIDAS

and Satellites



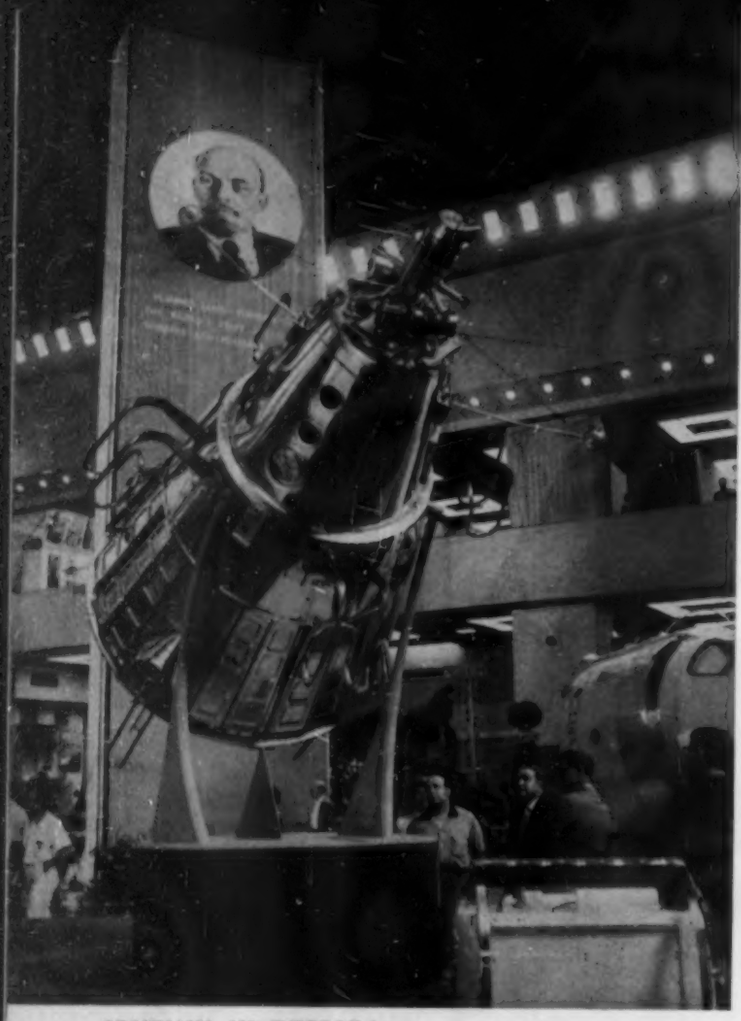
X-15

X-15 (Air Force-Navy-NASA)

Type: Manned R&D rocket plane
Status: R&D
Prime contractor: North American Aviation, Inc.
Performance: Range—400 n. miles. Speed—3600 mph. Ceiling—50-100 miles.
Frame: System contractor—North American. Length—50 ft. Launch weight—31,275 lbs. Landing weight—12,971 lbs. Capacity—18,304 lbs. Wingspan—22 ft.
Booster: System contractor—Thiokol. Propellant—LOX and liquid ammonia. Thrust—50,000 lbs. Type—XLR99.
Power units: System contractor—General Electric.
Remarks: The X-15 program is aimed at exploration of the atmosphere at the fringes of space.

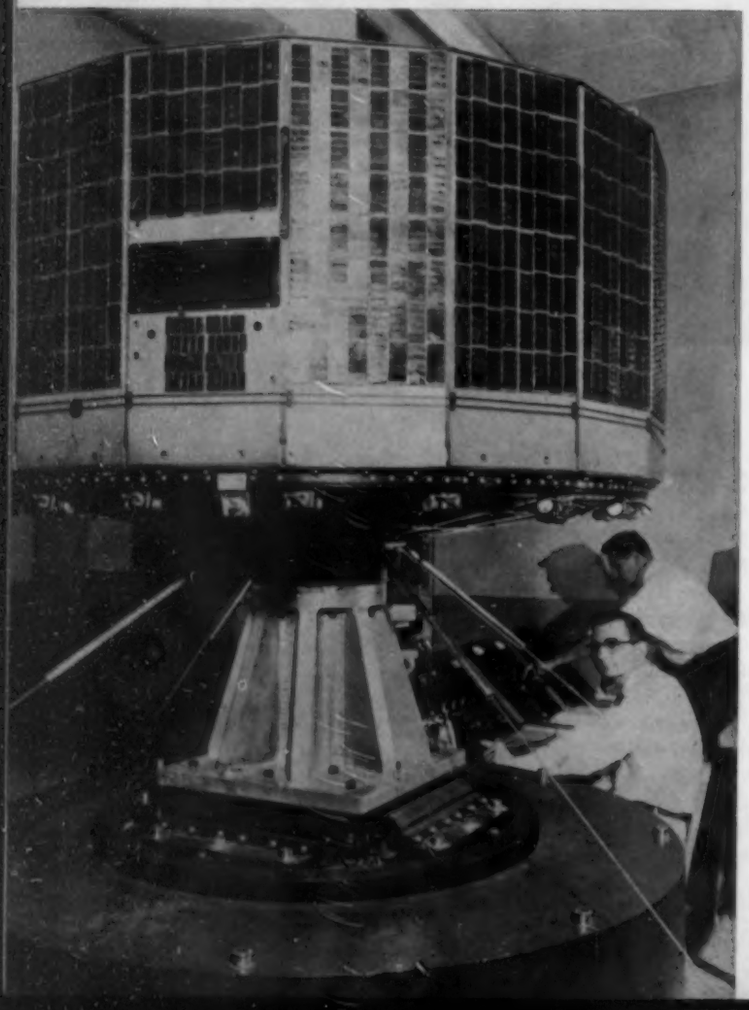
SAMOS (Air Force)

Type: Reconnaissance satellite
Status: R&D
Prime contractor: Lockheed Aircraft Co.
Performance: Orbit — Polar, several hundred miles.
Deployment: Initially operational—late 1963. Number of satellites—less than 6.
Instrumentation: System contractor—Lockheed.
Booster: System contractor—Convair. Type—Atlas. Propellant—liquid.
Sustainer: System contractor—Lockheed. Type—Agena. Propellant—liquid.
Remarks: Samos will provide a continuous reconnaissance of the world.



SPUTNIK III REPLICA

TIROS CHECKOUT



SPUTNIKS I to III (Russia)

Type: Data-collecting experimental satellites.
Status: No longer in orbit.
Performance: Orbits—(SI) 142/588; life 10/4/57 to 1/4/58. (SII) 140/1038; life 11/3/57 to 4/14/58. (SIII) 135/1167; life 5/15/58 to 3/15/60.
Frame: Diameter—(SI) 22.8 in. (SII) undisclosed. (SIII) 11 ft. 9 in. long, 5 ft. 8 in. wide at base. Launch weight—(SI) 184 lbs. (SII) 1120 lbs. (SIII) 2925 lbs.
Payload: (SI) transmitters, measuring instrumentation. (SII) transmitters, measuring instrumentation, dog "Laika." (SIII) transmitters, measuring instrumentation.
Boosters: In all three cases the Soviets used large military rockets. Thrust—about 600,000 lbs.
Power units: (SI) chemical batteries. (SII) chemical batteries. (SIII) chemical batteries and solar cells.

COURIER (Army-ARPA)

Type: Delayed-repeater communications satellite
Status: Operational 1960
Prime contractor: Army Signal Research and Development Laboratories.
Performance: Orbit—about 650 n. miles. Operational life—about 1 year.
Frame: System contractor—Philco Corp. Diameter—about 50 in. Launch weight—about 475 lbs.
Instrumentation: System contractor — Philco. Type — microwave receivers, VHF transmitters.
Booster: System contractor—Douglas. Type—Thor.
Sustainer: System contractor—Aerojet. Type—Able-Star.
Power units: Type—solar cells (about 20,000); nickel-cadmium batteries.
Remarks: Courier will be the nation's first active satellite communications system. Follow-on systems under development by ARPA and the Army and Air Force are generally lumped under the project name—Advent. These include polar-orbiting and 24-hour instantaneous repeater satellites.

TIROS (NASA)

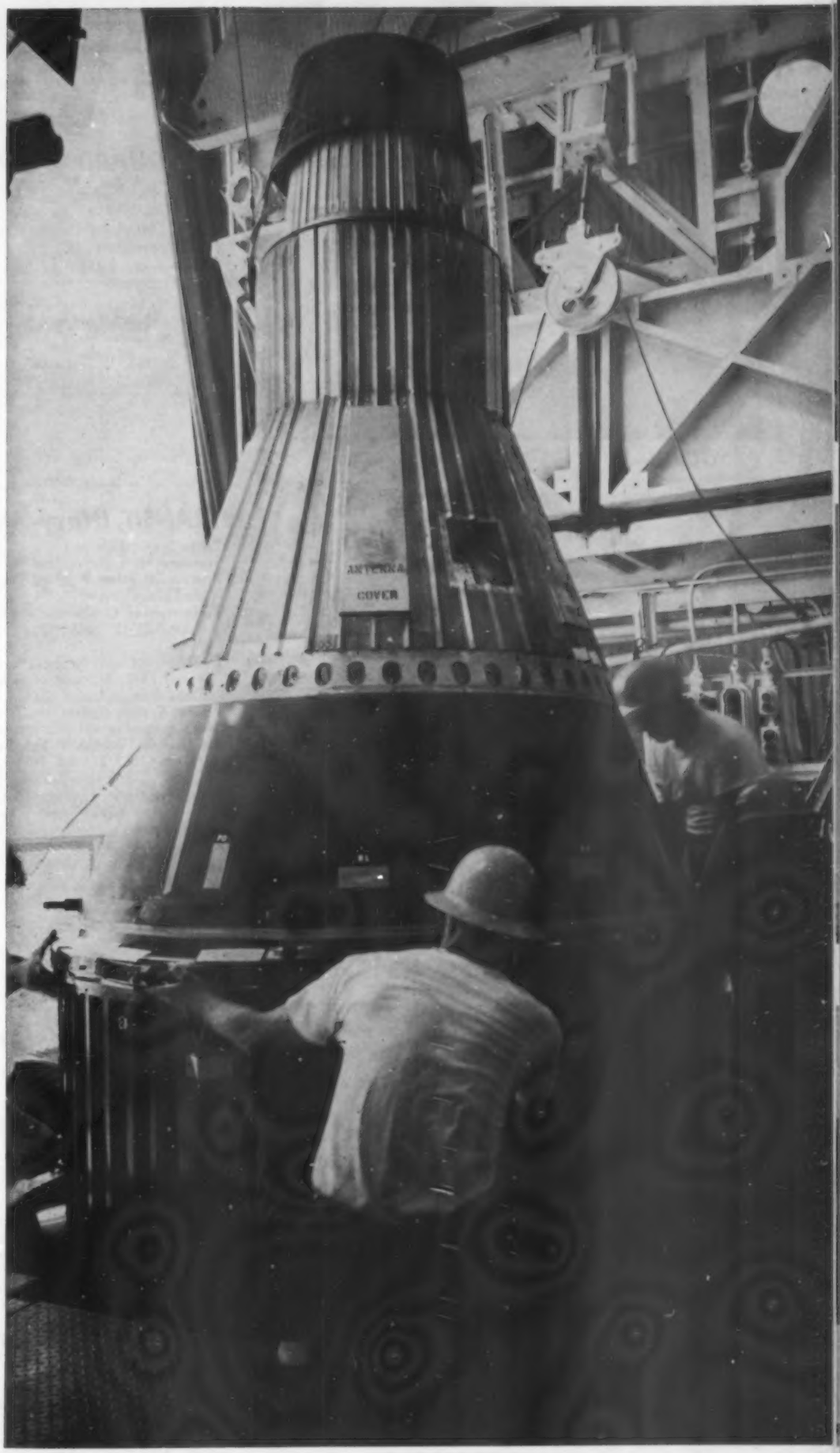
Type: Weather observation satellite
Status: R&D
Prime contractor: RCA
Performance: Photographs cloud cover and transmits on ground command.
Frame: System contractor—RCA. Diameter — 42 in. Height—19 in. Weight—270 lbs.
Instrumentation: System contractor—RCA. Types—Narrow and wide-angle camera, magnetic drag measurement.
Power units: System contractor—Hoffman Electronics. Type—solar cells.
Remarks: Tiros I transmitted 22,952 pictures during 78-day life. A second shot is planned for the fourth quarter of 1960. An advanced Nimbus weather satellite is scheduled for the fourth quarter of 1961.

MERCURY (NASA)

Type: Manned earth-orbiting capsule
Status: R&D
Prime contractor: McDonnell Aircraft Co.
Performance: Orbit—about 120 miles. Initially operational—1961.
Frame: System contractor—McDonnell. Length—9.5 ft. Diameter—6.5 ft. Weight—about 2000 lbs.
Instrumentation: System contractor—McDonnell. Types and functions — physio-psychological; attitude; navigation.
Boosters: System contractors—Convair/Redstone. Type — Atlas and Redstone. Propellant—liquid.
Power Units: System contractor —McDonnell. Type—battery. Life—mission plus 12 hours. Output—(6) 1500 watt/hour batteries.
Remarks: Initial flights call for boosting first unmanned, then manned capsules down the Atlantic Missile Range.

ECHO (NASA)

Type: Inflated balloon passive communications satellite
Status: R&D
Prime contractor: NASA
Performance: Reflect radio signals off surface of 100-ft. sphere.
Frame: Plastic film—G. T. Schjeldahl Co. Gas container—Kaiser Fleetwings Inc.
Instrumentation: None. Telemetry beacon in third stage rocket.
Power units: Mercury batteries.
Boosters: Thor-Delta.
Remarks: First attempt to launch sphere in 1000-mile circular orbit failed May 13.



MERCURY INSPECTION

VANGUARD

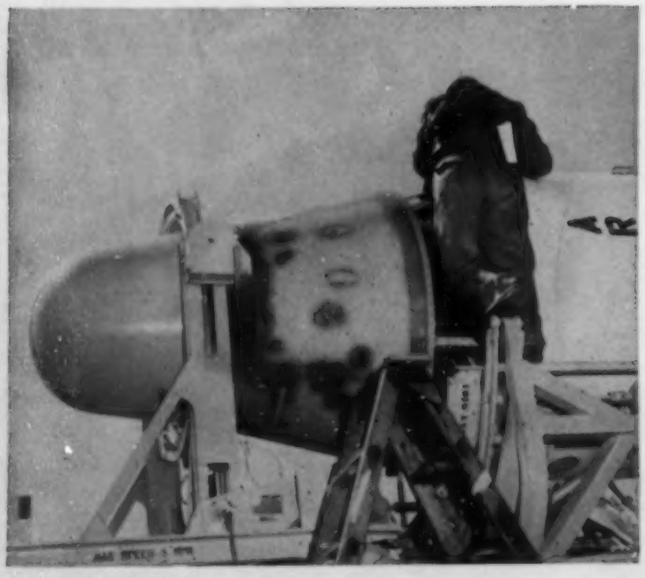
VANGUARD (NASA)

Type: Data-collecting experimental satellite
Status: Phased out
Prime contractor: NRL
Performance: Report on space environment
Frame: System contractor—NRL. Dimensions—Sphere 6 in. or 20 in. diameter.
Instrumentation: NRL. Types—measurement of temperatures, geodetic measurements.
Power units: Mercury batteries and solar converters
Remarks: Vanguard I, still transmitting, has provided important data on the shape of the earth.

TRANSIT

TRANSIT (Navy-ARPA)

Type: Navigation satellite.
Status: R&D
Prime contractor: Applied Physics Laboratory.
Performance: Orbit—about 500 n. miles. (2 polar, 2 equatorial.)
Deployment: Initially operational about 1962. Number of satellites—four.
Frame: System contractor—APL. Configuration—36 in. sphere. Weight—(Transit-1B) 265 lbs.; (Transit IIA) 223 lbs. (Operational weight about 50 lbs.)
Instrumentation: System contractor — APL. Type — two ultra-stable oscillators, IR scanner, electronic clock.
Booster: System contractor—Douglas. Type—Thor. Propellant—liquid.
Sustainer: System contractor—Aerojet. Type—Able-Star. Propellant—liquid.
Power Units: Solar cells and storage batteries.
Remarks: Transit IIA was successfully launched into a 563/460 mile orbit June 22, 1960. It carried a piggy-back satellite—NRL I—into orbit with it and released it, thereby becoming the first two-in-one satellite. Transit will enable surface ships and submarines—particularly Polaris submarines—to fix their position by better than a quarter of a mile.



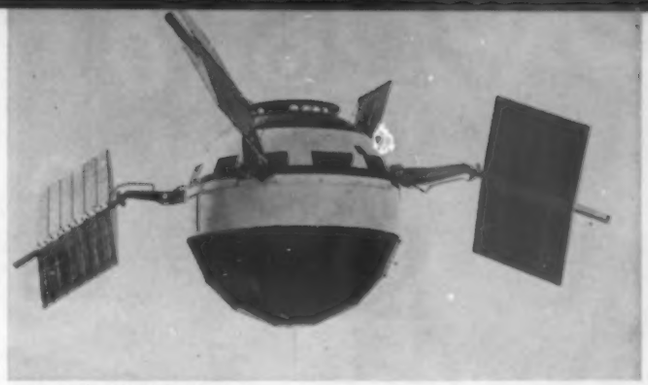
DISCOVERER

DISCOVERER (Air Force)

Type: Experimental military satellite series
Status: R&D
Prime contractor: Lockheed Aircraft Co.
Performance: Orbit—ellipitical and varied. (polar)
Frame: System contractor—Lockheed. Length—19.2 ft. Diameter—5 ft. Weight—about 1700 lbs.
Re-entry vehicle: System contractor — General Electric. Type—capsule. Length—27 in. Diameter—33 in. Weight—about 300 lbs.
Instrumentation: IR horizon scanner, telemetry, other instrumentation varied.
Booster: System contractor—Douglas. Type—Thor. Propellant—liquid.
Sustainer: System contractor—Lockheed. Type—Agena. Propellant—liquid.
Remarks: The Discoverer program beginning early in 1959 has launched a series of R&D satellites into orbit aimed at stabilization of a satellite in space and recovery of a capsule from orbit. While other objectives have been achieved, the Air Force failed to recover a capsule through the first dozen tries. The program calls for eventual recovery of mice and monkeys in the capsule, which would be either air-snatched by planes or picked up by ship. Discoverer is closely tied to the Samos and Midas programs.

PADDLEWHEEL (NASA)

Type: Data-collecting experimental satellite
Status: Operational
Prime contractor: STL
Performance: Report on space environment.
Frame: System contractor—STL. Dimensions variable. Weight —94 to 372 lbs.
Instrumentation: Various scientific groups. Types—Measurement of radiation, magnetism, radio background, aspect; photo scanning.
Power units: System contractor —Hoffman Electronics. Type —solar cells (on paddlewheel vanes).
Remarks: The Explorer VI satellite and the Pioneer V space probe were paddlewheel payloads. Another will be carried on the forthcoming Atlas-Able moon probe.



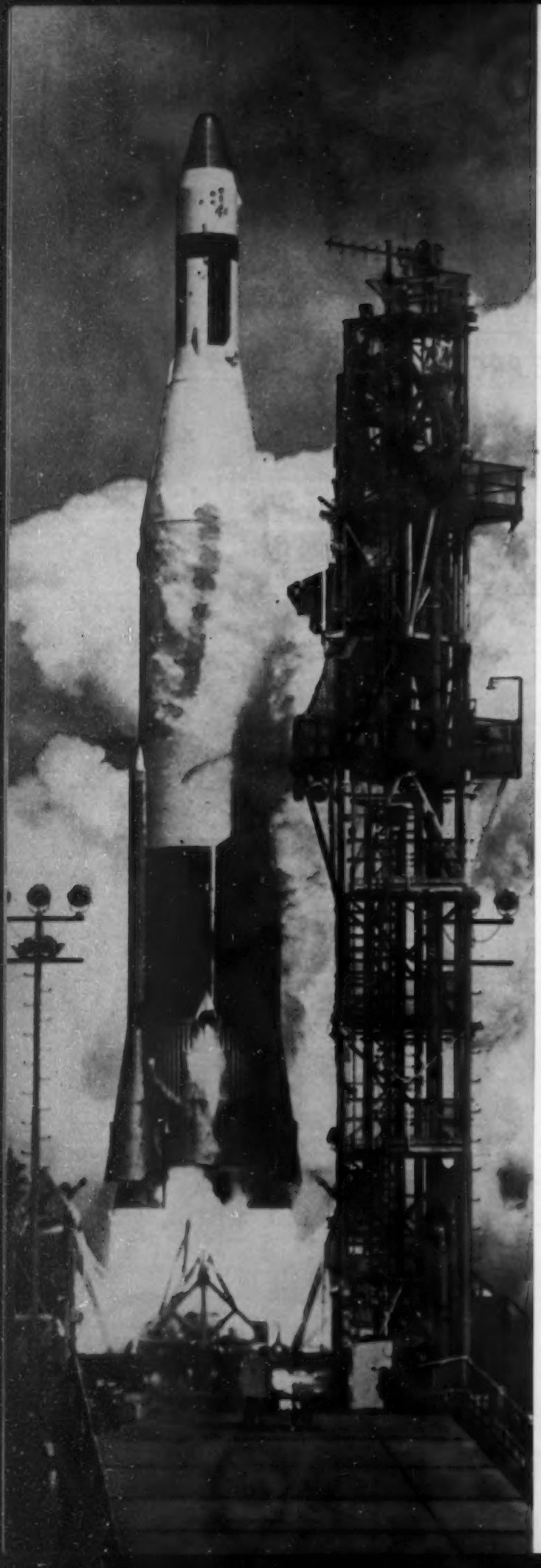
PADDLEWHEEL

DEEP SPACE PROBES

Name and Country	Weight (lbs.)	Launch Vehicle	Launch Date	Trajectory and Purpose	Remarks
LUNIK I (MECHTA), RUSSIA	3245	N.A.	1/ 2/59	Escape earth in direction of moon	Believed in 15 mo. solar orbit; passed within 5000 miles of moon
PIONEER IV, U.S.	13.4	JUNO II	3/ 3/59	Escape earth in direction of moon	In solar orbit of about 12 mo.; passed within 35,000 miles of moon
LUNIK II, RUSSIA	780 (incl. final stage)	N.A.	9/12/59	Lunar impact; radiation and magnetism measurements	Achieved impact
LUNIK III, RUSSIA	About 614	N.A.	10/ 4/59	Earth-moon orbit, apogee 291,000 mi., perigee 30,000 mi., very long lifetime	Took first picture of far side of moon
PIONEER V, U.S.	94.8	THOR-ABLE	3/11/60	Solar orbit between earth and Venus orbits; long-range radio communications; radiation, space environment measurements	Transmitted data more than 20 million miles; 5-watt transmitter weakening but still in operation

SATELLITES IN ORBIT

Name and Country	Weight (lbs.)	Launch Vehicle	Launch Date	Est. Life	Current Apogee & Perigee (mi.)	Purpose	Remarks
EXPLORER I, U.S.	30.8	JUPITER C	1/31/58	3-5 yrs.	1198.5; 216.8	Radiation measurement	Discovered Van Allen belt
VANGUARD I, U.S.	3.25	VANGUARD	3/17/58	200-1000 yrs.	2462.9; 405.7	Test VANGUARD concept	Solar battery-powered radio still operating
VANGUARD II, U.S.	20.7	VANGUARD	2/17/59	50 yrs.	2050.4; 345.8	Test weather-scan concept	
EXPLORER VI, U.S.	142	THOR-ABLE	8/ 7/59	1 yr.	26,357; 156 (at last report)	Radiation, space environment measurements	First "paddlewheel" satellite
VANGUARD III, U.S.	About 100	VANGUARD	9/18/59	30-40 yrs.	2321; 320.8	Radiation, space environment measurements	Ended VANGUARD program
EXPLORER VII, U.S.	91.5	JUNO II	10/13/59	20 yrs.	672.7; 343.7	Radiation, space environment measurements	Still transmitting some data
DISCOVERER V CAPSULE, U.S.	Under 300	THOR-AGENA	8/13/59	Several months	1074; 134	Carry satellite, which came down 9/28	Believed destroyed, later discovered & thought Russian
TIROS I, U.S.	270	THOR-ABLE	4/1/60	50-100 yrs.	468.3; 428.9	Picture-taking weather satellite	Transmitted 22,952 cloud-cover photos in 78-day instrument lifetime
TRANSIT IB, U.S.	265	THOR-ABLESTAR	4/13/60	16 mo.	454.6; 229	First R&D Navigational satellite	ABLESTAR achieved first known restart in space
SPUTNIK IV, Russia	10,008	N. A.	5/15/60	Fairly brief	409; 181	Test support systems, cabin for manned flight; attempted return from orbit	Original apogee 229, perigee 188; poor retro orientation spoiled return attempt
MIDAS II, U.S.	5000	ATLAS-AGENA A	5/24/60	40 mo.	319.6; 300.1	IR scanning for early warning of missile launchings	Telemetry failed 5/26; AGENA B restarted in space
TRANSIT II-A, U.S.	223	THOR-ABLESTAR	6/22/60	50 yrs.	650.4; 389.1	Second R&D navigational satellite	Carried "piggyback" for first twin satellite launching
GREB, U.S.	40	THOR-ABLESTAR	6/22/60	50 yrs.	650.4; 389.1	Radiation measurements	Passenger aboard TRANSIT II-A



SPACE VEHICLES

ATLAS-AGENA (Air Force and NASA)

Type: Launch vehicle

Status: Operational with Agena A. R&D with Agena B.

Prime contractor: None

Performance: (Payload in 300-mile orbit): Agena A—3600. Agena B 5300. Agena B will accelerate 800 lbs. to escape velocity.

Frame: Manufacturers—Convair, Lockheed. Length overall—99-101 ft. Diameter—10 ft. Gross weight—Agena A 265,000 lbs., Agena B 275,000 lbs. Major material—steel.

Propulsion: All liquid.

Guidance: (Only Agena B) Minneapolis-Honeywell. Type: All-inertial.

Stages: 1. Modified Atlas ICBM. 2. Agena. Engine—Bell XLR-81.

Remarks: Atlas-Agena A first flown successfully May 24, 1960, to launch Midas II. Atlas-Agena B to begin service in 1961.

ATLAS-ABLE (NASA)

Type: Early deep space launch vehicle.

Status: Two shots this year, then phase-out.

Prime contractor: None.

Performance: Escape velocity—800 lbs.

Frame: Length—112 ft. Diameter—10 ft. Gross weight—255,000 lbs.

Propulsion: 2 liquid stages, 1 solid.

Guidance: Only in booster stage.

Stages: 1. Modified Atlas ICBM. 2. Able. 3. Hercules-ABL Altair.

Remarks: First two shots failed in 1959. Shortage of Atlas vehicles delayed backup shot until this summer or fall.

SCOUT (NASA)

Type: Launch vehicle for small satellites.

Status: R&D.

Prime contractor: NASA Langley Research Center.

Performance: 300-mile orbit—about 200 lbs.

Frame: Manufacturer—Chance Vought. Length overall—72 ft. Diameter—40 in. Gross weight—36,100 lbs. Major materials—steel and plastic.

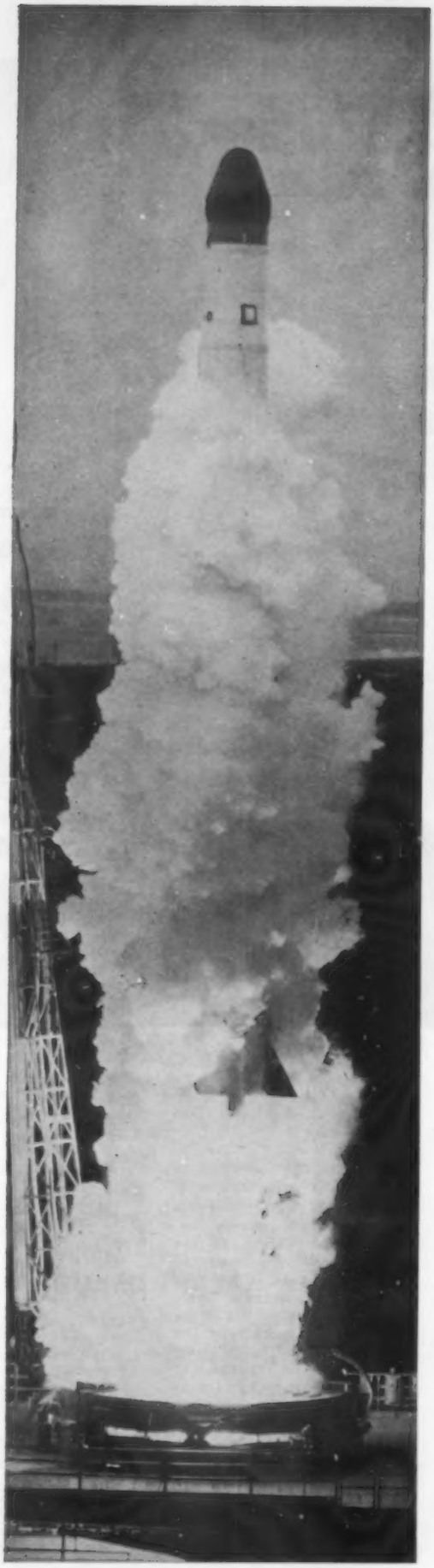
Propulsion: All solid. .

Stages: 1. Aerojet Algol. 2. Thiokol Castor. 3. Hercules-ABL Antares. 4. Hercules-ABL Altair.

Guidance: Minneapolis-Honeywell. Type—semi-inertial.

Remarks: Flight tests of full vehicle began this month; to be operational this year. After next year will replace all liquid-propelled vehicles for orbiting small payloads. Air Force has similar vehicle called Hyper-Environmental Test System 609A.

LEFT: ATLAS-AGENA



THOR-ABLESTAR

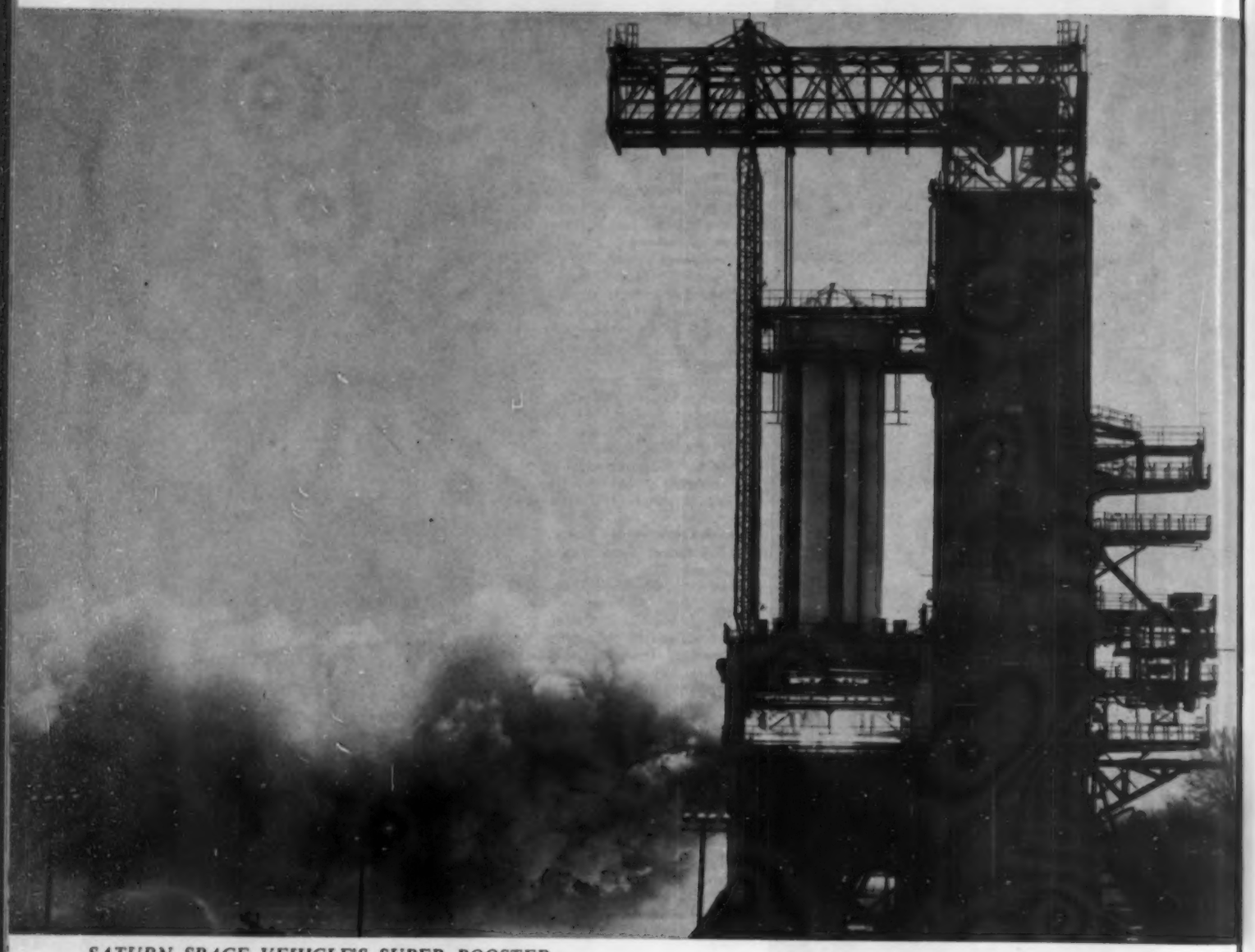
THOR-ABLE, THOR-ABLESTAR, THOR-DELTA (Air Force, NASA)

Type: Launch vehicle
Status: Thor-Able now phased out. Thor-Ablestar operational. Thor-Delta becoming operational.
Prime contractor: Douglas, except Aerojet-General for Ablestar vehicle stage.
Performance (payload in 300-mile orbit: Able—200 lbs. Ablestar—800 lbs. Delta—480 lbs.
Frame: Length overall—Able & Delta 92 ft., Ablestar 90 ft. Diameter—8 ft. Gross weight—Able 105,000 lbs. Ablestar 110,000 lbs. Delta 112,000 lbs. Major material—aluminum.
Propulsion: Able & Delta 2 liquid stages and one solid. Ablestar 2 liquid.
Guidance: (only Delta) Bell Telephone. Type: radio command.
Stages: 1. Modified Thor IRBM. 2. Able, Ablestar or Delta. 3. (Able and Delta only) Hercules-ABL Altair.
Remarks: The original Thor-Able, which made use of upper stages developed for Vanguard, was used successfully in some of this country's earliest launches. Thor-Ablestar, with a restartable, scaled-up Able, is used in the Navy's Transit program and will be used for the Army's Courier satellites. Delta, which coasts for 15 minutes before ignition of the guided third stage, is used for the Echo 100-ft. balloon satellite and a variety of other NASA programs.

CENTAUR (NASA)

Type: Multipurpose launch vehicle.
Status: R&D.
Prime contractor: Convair.
Performance: 300-mile orbit—8500 lbs. Escape velocity—1450 lbs.
Frame: Length overall—105 ft. Diameter—10 ft. Gross weight—291,000 lbs. Major material—steel, aluminum.
Stages: 1. Modified Atlas ICBM. 2. Centaur. Manufacturer—Convair; engines—Pratt & Whitney LR-115 (2).
Guidance: Minneapolis-Honeywell. Type—all-inertial.
Remarks: First flight 1961. Will provide for the first time U.S. lift capacity equal to Sputnik I and will be most powerful U.S. vehicle until Saturn is available.

THOR-ABLE IV



SATURN SPACE VEHICLE'S SUPER BOOSTER

SATURN C-1 (NASA)

Type: Multipurpose launch vehicle for very heavy payloads.

Status: R&D.

Prime contractor: NASA Marshall Center.

Performance: 300-mile orbit—22-25,000 lbs. Escape velocity—9000 lbs.

Frame: Length overall (without payload)—150 ft. Diameter—22 ft. Gross weight—1,000,000 lbs. Major material—aluminum.

Propulsion: All liquid.

Guidance: NASA Marshall center. Type—all-inertial.

Stages: 1. Saturn booster. Manufacturer—NASA Marshall Center; engines—Rocketdyne H-1 (8).

2. S-4. Manufacturer-Douglas; engines—Pratt & Whitney LR-115 (4)

3. S-5. Manufacturer-Convair; engines—Pratt & Whitney LR-115 (2)

Remarks: First flight 1961 with dummy upper stages. First three-stage vehicle flight 1963. Operational 1964. Next vehicle, Saturn C-2, will have stage made of 4 Rocketdyne J-2 engines inserted between first and second stages of C-1. A third Saturn may be an all-chemical vehicle with another J-2 stage inserted just above the J-2 stage in the C-2, or it may be a chemical-nuclear vehicle.

The Saturn program, begun under ARPA and the Army and transferred to NASA this year, is the civilian space agency's "main chance" space vehicle in the international space race. The Saturn vehicle in its later forms will be capable of sending a manned spacecraft around the moon. It also will be capable of putting into orbit around the earth multi-ton segments of a space station for assembly there.

THOR-AGENA (Air Force and NASA)

Type: Launch vehicle
Status: Operational with Agena A. R&D with Agena B.
Prime contractor: None
Performance: Agena A—300 lbs. in 300-mile orbit. Agena B—1600 lbs. in 300-mile orbit.
Frame: Manufacturers—Douglas, Lockheed. Length overall—Agena A 78.6 ft., Agena B 81 ft. Diameter—8 ft. Gross weight—Agena A 118,500 lbs., Agena B about 123,000 lbs. Major material—aluminum
Propulsion: All liquid.
Guidance: (Only Agena B) Minneapolis-Honeywell. Type: All-inertial.
Stages: 1. Modified Thor IRBM. 2. Agena. Engine—Bell XLR-81.
Remarks: Thor-Agena A in use in Discoverer program. Thor-Agena B, with restartable upper stage, will be used by both Air Force and NASA beginning in 1961.

JUNO II (NASA)

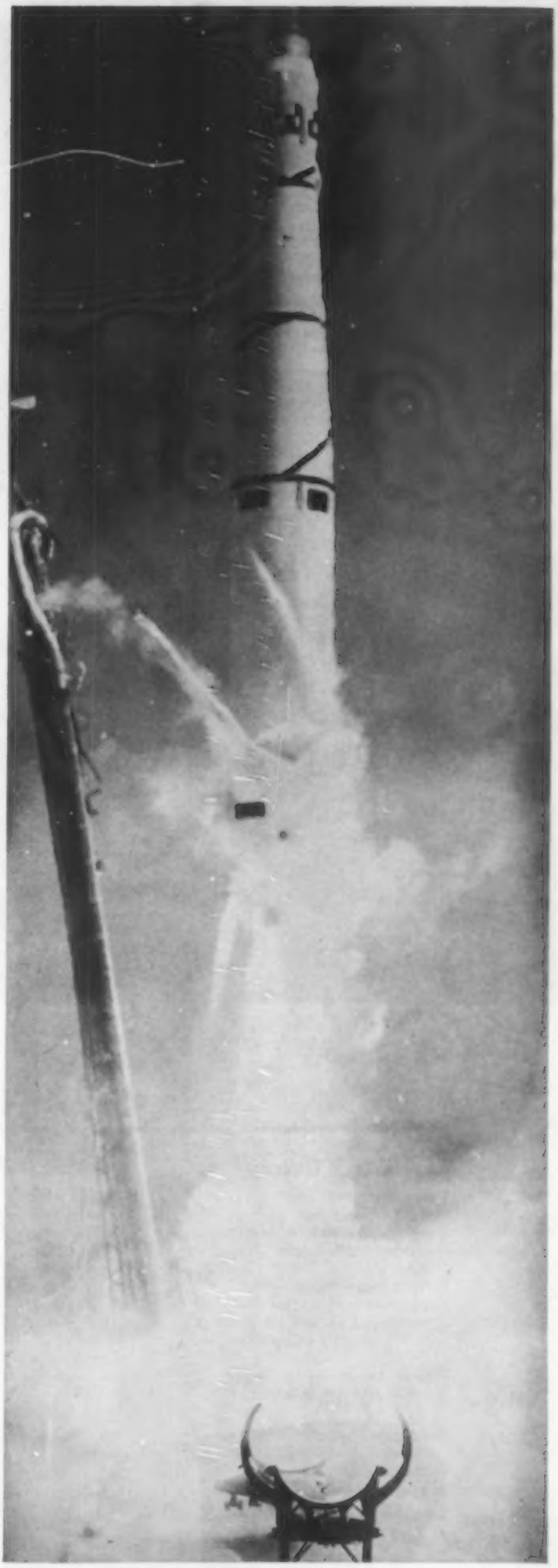
Type: Early launch vehicle.
Status: Operational.
Prime contractor: NASA Marshall Center.
Performance: 300-mile orbit—100 lbs. Escape velocity—13½ lbs.
Frame: Length overall—77 ft. Diameter—8¾ ft. Gross weight—122,000 lbs. Major material—aluminum.
Propulsion: 1 stage liquid, 3 solid.
Guidance: Upper stage unguided except spin.
Stages: 1. Modified Jupiter IRBM. 2. Cluster of 11 scaled-down Sergeants. 3. Cluster of 3 scaled-down Sergeants. 4. Scaled-down Sergeant.
Remarks: Launched 3 Pioneers and one Explorer. Four more shots planned this year and next.

JUPITER C (Army)

Type: Launch vehicle.
Status: Phased out.
Prime contractor: ABMA.
Performance: 300-mile orbit—30 lbs.
Propulsion: 1 liquid, 3 solid.
Guidance: Upper stages unguided except spin.
Stages: 1. Modified Redstone missile. 2. Cluster of 11 scaled-down Sergeants. 3. Cluster of 3 scaled-down Sergeants. 4. Scaled-down Sergeant.
Remarks: Orbited Explorer 1, America's first satellite.

VANGUARD (NASA)

Type: Early launch vehicle.
Status: Phased out.
Performance: Up to 100 lbs. in 300-mile orbit.
Prime contractor: Martin.
Frame: Length—72 ft. Diameter—45 in. Gross weight—22,600 lbs.
Propulsion: 2 liquid stages, 1 solid.
Guidance: Minneapolis-Honeywell. Type—Semi-inertial.
Stages: 1. General Electric X405. 2. Aerojet-General Liquid AJ 10. 3. Hercules-ABL solid X248 (earlier versions used Grand Central Meteor).
Remarks: Orbited three satellites. Components and techniques used in many subsequent space programs.



DISCOVERER ON THOR AGENA

Foreign Missiles

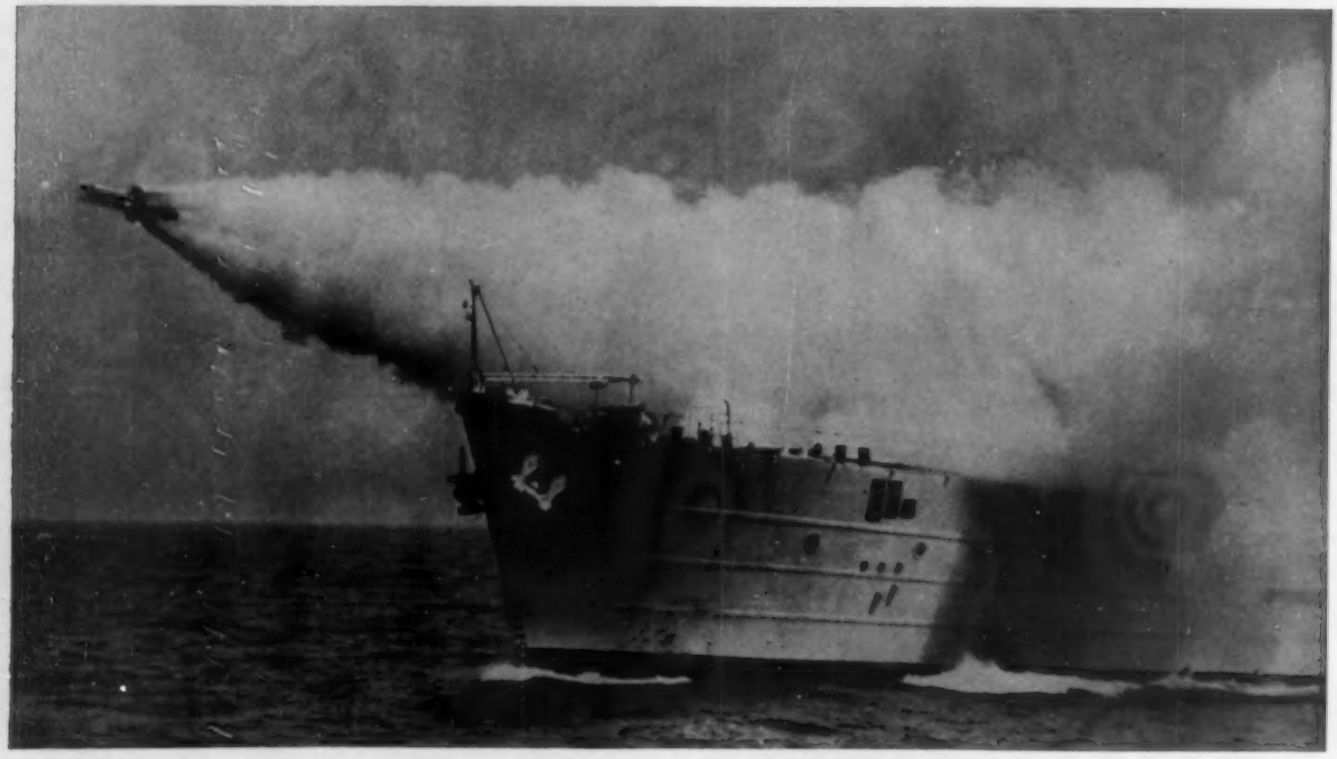
Russia and the United States continue to dominate the world of missilery.

Russia's already large rockets appear to be getting larger as the Soviets push further into space. Meantime, the Soviets are reported to be improving their missile air defenses and rapidly increasing their ICBM strength and their already huge arsenal of tactical missiles.

The other nations of the world continue to lag behind in the field of big missiles. But much work is going on in almost every industrialized country in development of smaller tactical missiles and research rockets.

Next to Russia and the United States, Britain and France are farthest along. Japan also is beginning to move ahead swiftly.

Red China remains a question mark. The Red Chinese are reported to have some missiles and to be developing a nuclear bomb. But the missiles, at least for the present, apparently are of Russian origin.



SEASLUG

GREAT BRITAIN

SEASLUG (Navy)

Type: Surface-to-air
Status: Operational
Prime contractor: W. G. Armstrong Whitworth Aircraft, Ltd.
Performance: Range—long.
Deployment: Location—to be deployed aboard Navy cruisers. Initially operational—1960.
Frame: Length—19.5 ft. Diameter—1.5 ft. Wingspan—4.5 ft.
Guidance: System contractor—General Electric. Type—beam riding.
Booster: Type—solid (4).
Sustainer: Type—solid.
Payload: Warhead type—HE (nuclear later).

FIREFLASH (RAF)

Type: Air-to-air
Status: Operational (training)
Prime contractor: Fairey Aviation Ltd.
Performance: Range — several miles. Speed — more than Mach 2.
Deployment: Location — RAF squadrons use for training.
Frame: Length—7 ft. 5 in. Wing span—28.1 in. Diameter—5.5 in. Launch weight—300 lbs.
Guidance: Type—beam riding.
Booster: Type—solid. Number—two.
Payload: Type—HE.
Remarks: Fireflash has been replaced as an operational missile by the Firestreak.

BLUE STEEL (RAF)

Type: Air-to-surface (tactical)
Status: R&D
Prime contractor: A. V. Roe & Co., Ltd.
Performance: Range—about 400 miles. Speed—supersonic. Ceiling—about 60,000 ft.
Deployment: Location—to be air-launched from British V-bombers.
Frame: Length—36 ft. Wingspan—about 13 ft. Launch weight—about 15,000 lbs.
Guidance: System contractor—Elliott. Type-inertial.
Powerplant: Propellant—liquid
Booster: System contractor—de Havilland. Propellant—liquid. Thrust—16,000 lbs.
Payload: Warhead type—nuclear or HE.

BLOODHOUND I (RAF)

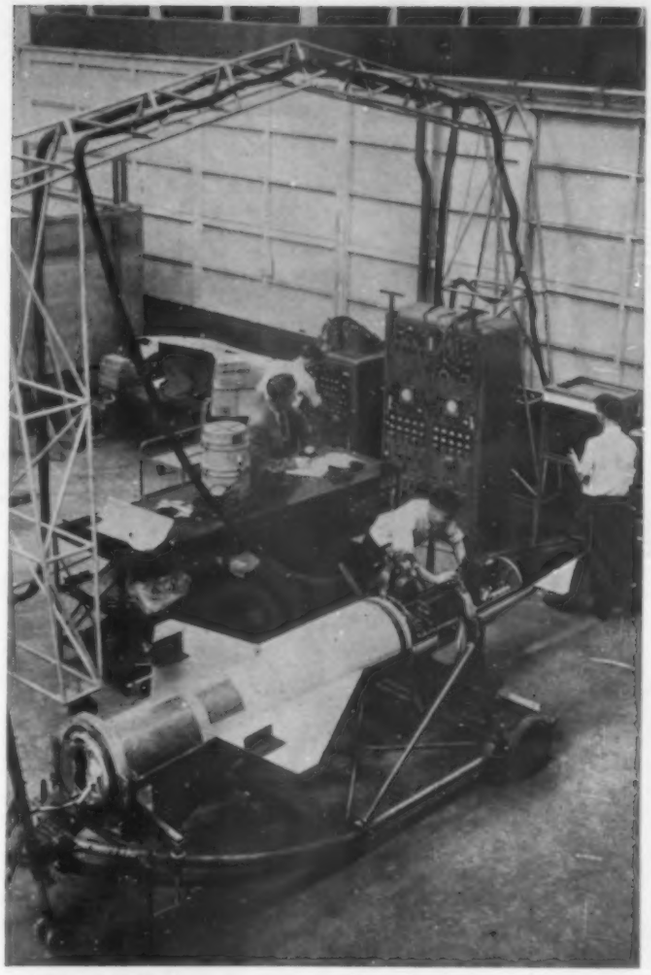
Type: Air-breathing surface-to-air
Status: Operational
Prime contractor: Bristol Aircraft Ltd.
Performance: Range—about 35 miles. Speed—Mach 2.3.
Deployment: Location—combat units in Britain and Australia. Also has been sold to Sweden.
Frame: Length—25.2 ft. Launch weight—4500 lbs.
Guidance: System contractor—Ferranti, Ltd. Type—radar homing.
Boosters: Type—solid (4)
Sustainers: System contractor—Bristol-Siddeley. Engine—Thor ramjets. Thrust—total 15,000 lbs.
Remarks: Bristol Aircraft is developing an advanced version called Bloodhound II. It will have anti-missile capability.

Pye P.V.

Type: Surface-to-surface (anti-tank)
Status: R&D
Prime contractor: Pye, Ltd.
Performance: Not available.
Frame: Length—5 ft. Fin span—2 ft. Launch weight—80 lbs.
Booster: Propellant—solid
Guidance: Type—wire.
Powerplant: Type—2 stage solid.
Remarks: Proposals submitted.

SEACAT (Navy)

Type: Surface-to-air
Status: Operational
Prime contractor: Short Bros. and Harland Ltd.
Performance: Range—short.
Deployment: Location—aboard Royal Naval destroyers and cruisers. Also ordered by Swedish, Australian and New Zealand navies. Initially operational—1960.
Guidance: Type—radio command.
Frame: Length—4 ft. 10 in. Wingspan—2 ft.
Booster: Type—solid.
Sustainer: Type—solid.
Payload: Warhead type—HE.
Remarks: Four missiles on one battery.



BLUE STEEL

SEACAT

VIGILANT

Type: Surface-to-surface (anti-tank)
Status: Operational
Prime contractor: Vickers-Armstrongs, Ltd.
Performance: Range—about 1700 yards. Speed—350 mph.
Deployment: None. NATO countries considering.
Frame: Length—3 ft. Diameter—4.5 ft. Launch weight—about 26 lbs.
Guidance: Type—wire.
Booster: Propellant—solid
Remarks: Designed for use by infantrymen.

RED TOP (RAF)

Type: Air-to-air
Status: R&D
Prime contractor: De Havilland Propellers, Ltd.
Performance: Range—about 9.5 miles. Speed—supersonic.
Deployment: Location—to replace Firestreak on various aircraft.
Guidance: Type—infrared.
Booster: Type—solid.
Payload: Warhead type—HE (68 lbs.).
Remarks: Apparently designed within the same concept as the U.S. Navy's Eagle.

TIGERCAT

Type: Surface-to-air
Status: R&D
Prime contractor: Short Brothers and Harland Co., Ltd.
Performance: Designed as mobile anti-aircraft to be launched from armored carriers.
Remarks: Under consideration by British Army.

FAIREY A-T (Army)

Type: Surface-to-surface (anti-tank)
Status: Study
Prime contractor: Fairey Engineering, Ltd.
Performance: Not available.
Guidance: Type—reported to be radar.

THUNDERBIRD (Army)

Type: Surface-to-air
Status: Operational
Prime contractor: English Electric Aviation, Ltd.
Performance: Range — 25 n. miles. Speed—about Mach 2.
Deployment: Location — with British Army combat troops. Initially operational—1959.
Guidance: System contractor—Marconi Instruments. Type—radar homing.
Booster: System contractor: D. Napier. Type—solid (4).
Sustainer: System contractor: D. Napier. Type—solid.
Payload: Warhead type—HE.
Remarks: Launched from mobile carriers. Advanced Thunderbird with low-level capability and increased range under development.

THUNDERBIRD

BLUE WATER (Army)

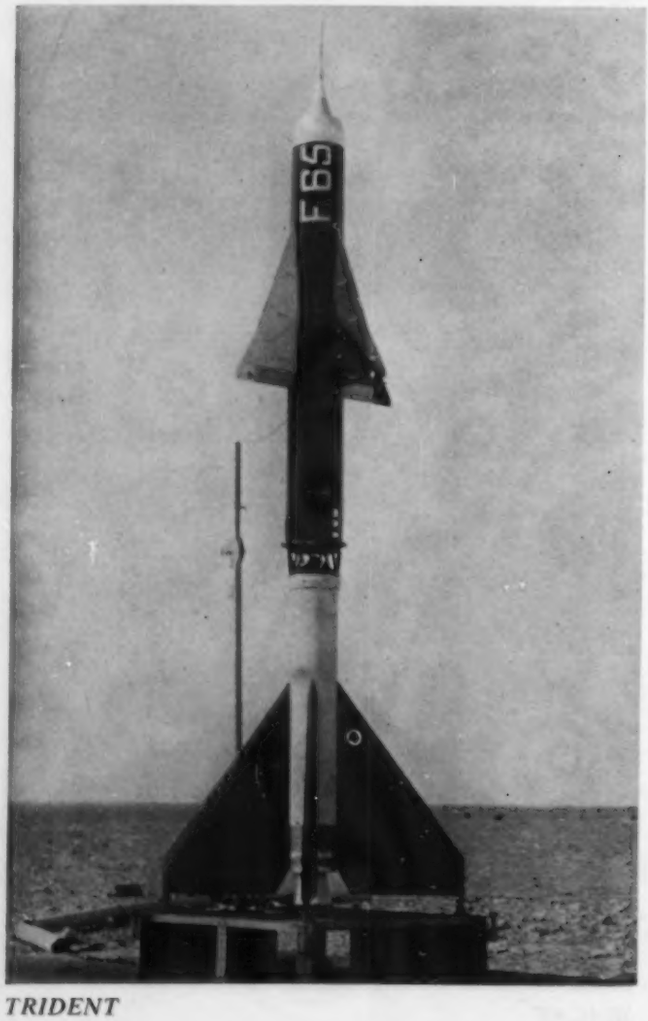
Type: Surface-to-surface (tactical)
Status: Operational
Prime contractor: English Electric Aviation Co., Ltd.
Performance: Range—about 100 miles.
Deployment: British Combat troops. Also sold to West German Army.
Booster: Type—solid.
Payload: Warhead type—nuclear or HE.
Remarks: Highly mobile.

FIRESTREAK (RAF)

Type: Air-to-air
Status: Operational
Prime contractor: De Havilland Propellers, Ltd.
Performance: Range—about 4.5 miles. Speed—Mach 2.3.
Deployment: Location — with RAF squadrons and air units of the Royal Navy.
Frame: Length—10.5 ft. Diameter—3.5 in. Launch weight —300 lbs.
Guidance: Type—infrared.
Booster: Type—solid.
Payload: Type—HE.

BLUE STREAK (RAF)

Type: IRBM surface-to-surface
Remarks: Program cancelled 1960.



TRIDENT

FRANCE

TRIDENT (Army)

Military designation: SE 4400
Type: Air-breathing surface-to-air.
Status: R&D
Prime contractor: Sud-Aviation
Performance: Range—24.8 n. miles. Speed—Mach 3.3. Ceiling—164,000 ft.
Deployment: Location—to be used for French space experiments.
Frame: Length—26.5 ft. Launch weight—2640 lbs.
Guidance: Type—radar homing.
Booster: Type—solid.
Sustainer: Type—ramjet.
Payload: Warhead type—HE.

MARUCA (Navy)

Type: Surface-to-air
Status: Operational (training)
Prime contractor: Ruelle Naval Arsenal
Performance: Range—about 10 n. miles.
Deployment: Location — used aboard French Experimental Missile Ship Ile-D'Oléron (converted transport) for training.
Frame: Length—15 ft. Wingspan—5 ft.
Guidance: Type—radar command.
Booster: Type—solid (4).
Sustainer: Type—liquid (nitric acid/aniline).
Payload: Warhead type—HE.
Remarks: Development vehicle for Masurca.

ACAM 5301 (Army)

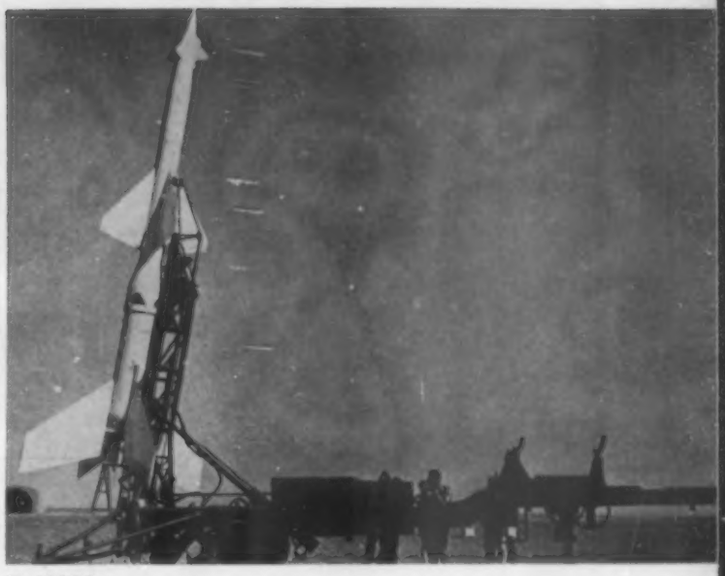
Type: Surface-to-air
Status: R&D
Prime contractor: Nord Aviation
Performance: Range—nearly 10 n. miles. Speed—about Mach 2.
Deployment: Location—to be deployed with Army combat troops, particularly for use against low-flying aircraft.
Frame: Length—14.5 ft. Wingspan—about 5 ft. Launch weight—1600 lbs.
Guidance: Type—radar.
Booster: Type—solid.
Sustainer: Type—solid.
Payload: Warhead type—HE (nearly 90 lbs.)

MASURCA (Navy)

Type: Surface-to-air
Status: Operational
Prime contractor: Ruelle Naval Arsenal
Performance: Range—more than 20 n. miles. Speed—Mach 2.6.
Deployment: Location—to be installed aboard French warships as the French Navy's top air defense weapon. Initially operational—1960.
Frame: Length—18.5 ft. Wingspan—3 ft. Launch weight—3200 lbs.
Guidance: Type—radar beam rider.
Booster: Type—solid.
Sustainer: Type—solid.
Payload: Warhead type—HE (220 lbs.)

R-422B2 (Army)

Type: Surface-to-air
Status: Operational
Prime contractor: MATRA
Performance: Range—about 40 n. miles. Speed—Mach 2.6.
Deployment: Location—metropolitan France. Initially operational—1960.
Frame: Length—30.5 ft. Launch weight—3500 lbs.
Guidance: Type—radar command and homing.
Booster: Type—solid.
Sustainer: Type—solid.
Payload: Warhead type—HE (110 lbs.).
Remarks: R-422B2 is mobile. MATRA R-431, designed to intercept high-altitude supersonic bombers, is under development. R-431 will be powered by a solid booster and a Nord ramjet.



R-422B2

MALAFAC (Navy)

Type: Surface-to-surface
Status: R&D
Prime contractor: Societe Industrielle D'Aviation Latecoere
Performance: Range—about 25 n. miles.
Deployment: Location—to be installed aboard French surface warships.
Frame: Length—20.5 ft.
Guidance: Radio command.
Booster: Type—solid.
Sustainer: Type—liquid (acid/furaline).
Payload: Warhead type—HE.
Remarks: Malafac test missiles have been launched many times at sea.

CAISSEUR (Army)

Military Designation: SE4200
Type: Air-breathing surface-to-surface (tactical)
Status: Operational
Prime contractor: Sud-Aviation
Performance: Range—16 to 55 n. miles. Speed—Mach .8.
Deployment: Location—French Army combat troops. Initially operational—1950.
Frame: Length—11.5 ft. Wingspan—9 ft. 9 in. Launch weight—2075 lbs.
Guidance: Type—radar command.
Booster: Type—solid (2).
Sustainer: Engine—ramjet.
Payload: Warhead type—HE.
Remarks: Launched from mobile carrier.

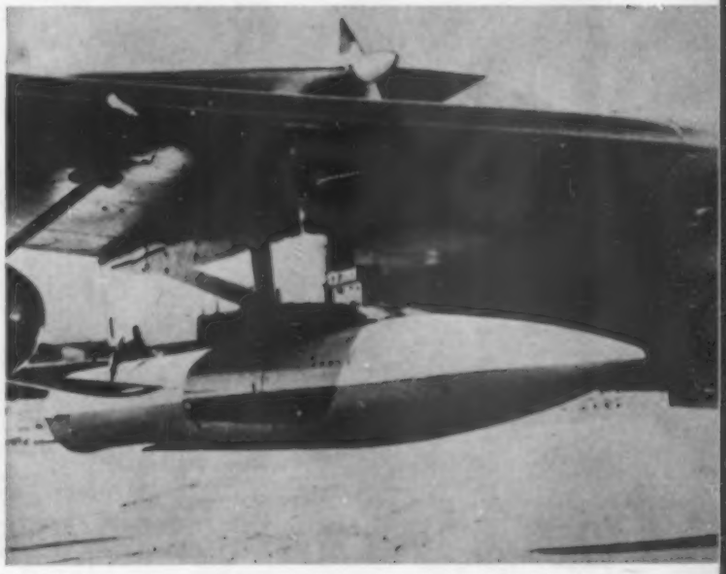
CAISSEUR

AA-20 (Air Force)

Type: Air-to-air and air-to-surface
Status: Operational
Prime contractor: Nord Aviation
Performance: Range—2.5 miles. Speed—supersonic.
Deployment: Location—in hands of Air Force and Navy units.
Frame: Length—8.5 ft. Launch weight—(a/a version) 300 lbs. (a/s version) between 295 and 375 lbs.
Guidance: Type—radio command.
Booster: Type—solid.
Sustainer: Type—solid.
Payload: Warhead type—HE.
Remarks: Nord has an adaptation of the AA-20—the ACAM 5301—under development for the French Army. Also the follow-on AA-30 for the Air Force.

R-511 (Air Force)

Type: Air-to-air
Status: Operational
Prime contractor: MATRA
Performance: Range—about 5 miles. Speed—supersonic.
Deployment: Location—carried aboard French interceptors.
Frame: Length—10 ft. Diameter—10 in. Launch weight—about 400 lbs.
Guidance: Type—radar homing.
Booster: System contractor—Hotchkiss-Brandt. Type—solid. Thrust—3500 lbs.
Sustainer: System contractor—Hotchkiss-Brandt. Type—solid. Thrust—440 lbs.
Payload: Warhead type—HE.
Remarks: To be replaced by advanced MATRA R-530 about 1962.



R-511

SS-12 (Army)

Type: Surface-to-surface (anti-tank)
Status: R&D.
Prime contractor: Nord Aviation.
Performance: Range—more than 4 miles. Speed—Mach 1.
Deployment: Location—to be deployed with French Army combat troops. Also, can be launched from light aircraft and helicopters.
Frame: Length—about 6 ft. Wingspan—about 32 in. Launch weight—150 lbs.
Guidance: Type—wire. Also radar version.
Booster: Type—solid.
Payload: Warhead type—nuclear and HE.
Remarks: SS-12 scheduled to be in production by May 1961. SS-12 is an advanced version of the Nord SS-10 and SS-11 (See U.S. missiles) which are in the hands of a large number of NATO armies.

MASALCA (Navy)

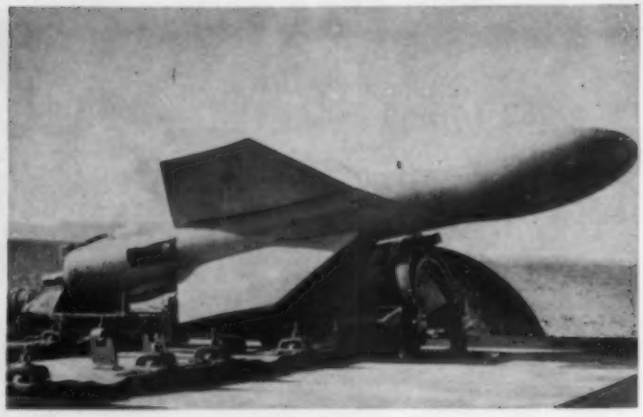
Type: Air-breathing surface-to-air
Status: Nearly operational
Prime contractor: Societe Industrielle d'Aviation Latecoere
Performance: Range—about 65 n. miles.
Deployment: Location—aboard French cruisers. Initially operational—1960.
Frame: Launch weight—6000 lbs.
Guidance: Type—beam rider.
Booster: Type—solid.
Sustainer: Type—ramjet.
Payload: Warhead type—HE.

SSBS-1

Type: IRBM surface-to-surface
Status: R&D
Prime contractor: Societe d'Etude et de Realisation d'Engins Balistiques
Performance: Range—2300 n. miles.
Payload: Warhead type—nuclear.

MALAFON (Navy)

Type: Surface-to-underwater (ASW)
Status: Nearly operational
Prime contractor: Societe Industrielle d'Aviation Latecoere
Performance: Range—more than 10 n. miles.
Deployment: Location—first deployed aboard the 3750-ton ASW Command Ship La Galissoniere. Initially operational—fall 1960.
Frame: Type — rocket-boosted homing torpedo similar to U.S. Navy's Asroc.
Guidance: Type—sonar and radio command.
Booster: Type—solid.
Payload: Warhead type—HE.



SS-12

BB-10 (Air Force)

Type: Air-to-surface
Status: Operational
Prime contractor: Sud-Aviation
Performance: Speed—Mach 1.
Deployment: Location — deployed with French Air Force.
Frame: Length—11 ft. Wingspan—2.5 ft. Launch weight—900 lbs.
Guidance: Type—radio command. (BB-10 carries TV camera so pilot can guide the missile to its target.)
Booster: Type—solid.
Payload: Warhead type—HE.

PARCA

ENTAC (Army)

Type: Surface-to-surface (anti-tank)
Status: R&D
Prime contractor: Nord Aviation
Performance: Range—about 1 mile. Speed—about 180 mph.
Guidance: Type—wire.
Booster: Type—solid.
Payload: Warhead type—HE.
Remarks: Recently turned over to Nord by DEFA.

PARCA (Army)

Type: Surface-to-air
Status: Operational
Prime contractor: DEFA
Performance: Range—15 miles. Speed—supersonic. Ceiling—80,000 ft.
Deployment: Location—in hands of French combat troops. Used mainly for training.
Frame: Length—18 ft. Launch weight—2200 lbs.
Guidance: System contractor—C. F. Thomson. Type—radar command.
Booster: Type—solid (4).
Sustainer: Type—solid.
Payload: Warhead type—HE.
Remarks: Advanced for use against Mach 3 aircraft under development.

ITALY

HSS-R 80/100

Type: Surface-to-surface (tactical)
Status: Operational
Prime contractor: Boscarri, Meccanemica, Hispano-Suiza
Deployment: Location—Egyptian troops.
Guidance: Type—free.
Booster: Type—solid.
Payload: Warhead type—HE.
Remarks: Bombardment rockets fired in salvoes of 20.

C-7 (Air Force)

Type: Air-to-air
Status. Nearly operational
Prime contractor: Societa Italiana Sviluppo Propulsione a Reazione
Performance: Range—6 miles. Speed—Mach 1.9.
Deployment: Location—aboard Italian Air Force interceptors.
Frame: Length—6.5 ft. Wingspan—25 in. Diameter—6 in. Launch weight—155 lbs.
Guidance: Type—infrared.
Booster: System contractor—Thiokol. Type—solid.
Payload: Warhead type—HE (55 lbs.)
Remarks: Later models to have alternate radar guidance and Italian booster.

AIRONE (Army)

Type: Surface-to-surface (tactical)
Status: Operational
Prime contractor: Polverificio Giovanni Stacchini
Performance: Range—6 miles.
Guidance: Type—free.
Booster: Type—solid.

SWITZERLAND

RSD-58

Type: Surface-to-air
Status: Operational
Prime contractor: Contraves AG and Oerlikon Machine Tool Works Buhrle & Co.
Performance: Range—18.6 miles. Speed—Mach 2.5. Ceiling—65,000 ft.
Deployment: Location—Combat units in Switzerland, Italy and Japan.
Frame: Length—20 ft. Launch weight—about 900 lbs.
Guidance: System contractor—Brown, Boveri & Co. Type—beam rider.
Booster: Type—liquid.
Payload: Warhead type—HE.
Remarks: RSA-54 is an earlier model. RSC-57 is a training model.

MOSQUITO (Army)

Type: Surface-to-surface (anti-tank)
Status: Operational
Prime contractor: Contraves AG and Oerlikon Machine Tool Works Buhrle & Co.
Performance: Range — about 6200 ft. Speed—200 mph.
Deployment: Location — Swiss Army units.
Frame: Length—3 ft. Launch weight—23 lbs.
Guidance: Type—wire.
Booster: Type—solid.
Sustainer: Type—solid.
Payload: Warhead type—HE (7 lbs.).

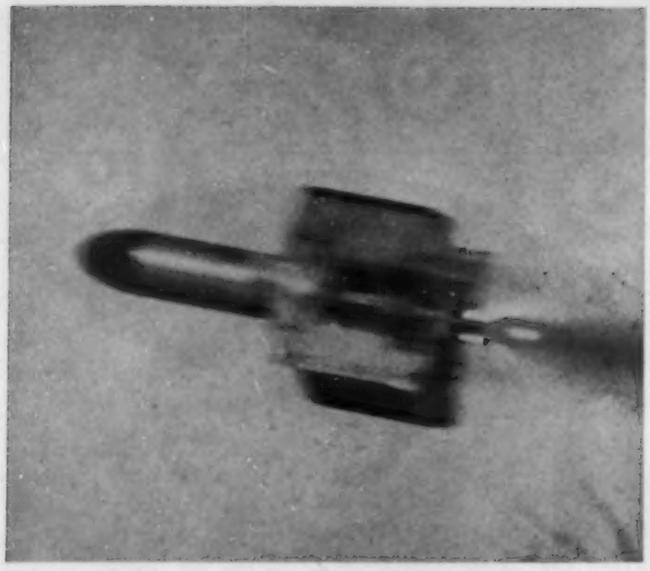
AUSTRALIA

MALKARA (Army)

Type: Surface-to-surface (anti-tank)
Status: Operational
Prime contractor: Government Aircraft Factories
Performance: Range—about 2 miles.
Deployment: Location — British combat troops.
Frame: Length—6.5 ft. Wingspan—2.5 ft. Launch weight—206 lbs.
Guidance: Type—wire.
Booster: Type—solid.
Sustainer: Type—solid.
Payload: Warhead type—HE (55 lbs.).

RSD-58

MOSQUITO



BANTAM

ROBOT 315

PSR-1

JAPAN

TLRM-1 (Army)

Type: Surface-to-air
Status: R&D
Prime contractor: Shin Mitshubishi, Mitshubishi Shipbuilding and Engineering Co.
Performance: Range — long. Speed—about 255 mph.
Frame: Length—10.5 ft. Launch weight—about 560 lbs.
Guidance: Type—possibly radar.

TMA-1 (Air Force)

Type: Air-to-air
Status: R&D
Prime contractor: Shin Mitsubishi and Mitsubishi Electrical.
Performance: Speed — supersonic.
Frame: Length—about 10 ft. Launch weight—more than 200 lbs.
Booster: System contractor—Fuji Precision. Type—solid.
Payload: Warhead type—HE.
Remarks: MM-1 is a test vehicle for the TMA-1.

TAAM-1D (Air Force)

Type: Air-to-air
Status: R&D
Prime contractor: Fuji Precision Machinery Co., Ltd.
Performance: Range—about 1.5 miles. Speed—Mach 1.5.
Frame: Length—8 ft. Launch weight—335 lbs.
Guidance: Type—infrared.
Payload: Warhead type—HE.

TATM-1 (Army)

Type: Surface-to-surface (anti-tank)
Status: R&D
Prime contractor: Kawasaki Kokuki Kogyu Kabushi-iki Kaisha
Frame: Length—4.5 ft. Launch weight—300 lbs.
Remarks: TATM-2 model also under development. It is 3.2 ft. long.

SWEDEN

ROBOT 315 (Navy)

Type: Surface-to-surface (tactical)
Status: Operational
Prime contractor: Swedish Guided Missile Bureau and Royal Swedish Armed Forces Research Establishment
Performance: Range—10 to 20 n. miles. Speed—Mach .9.
Deployment: Location—aboard Swedish Destroyers Halland and Smaland.
Frame: Length—24 ft. Launch weight—3000 lbs.
Guidance: Type—not available.
Booster: Type—solid (4).
Sustainer: Type—pulsejet.
Payload: Warhead type—HE.
Remarks: Torpedoboat model known as Sjorobot.

BANTAM (Army)

Type: Surface-to-surface (anti-tank)
Status: Operational
Prime contractor: A. B. Bofors
Performance: Range—6500 ft. Speed—190 mph.
Deployment: Location — with Swedish combat troops.
Frame: Length—2.5 ft. Launch weight—13 lbs.
Guidance: Type—wire.
Booster: Type—solid.
Sustainer: Type—solid.
Payload: Warhead type—HE (3.1 lbs.).
Remarks: Bantam can be fired from an infantryman's hip.

ROBOT 304 (Air Force)

Type: Air-to-surface
Status: Operational
Prime contractor: Swedish Guided Weapons Bureau and Royal Swedish Armed Forces Research Establishment.
Performance: Range—about 3 miles. Speed—Mach 1.
Deployment: Location—Swedish Air Force.
Frame: Length—14.5 ft. Launch weight—1000 lbs.
Guidance: Type—radio command.
Booster: Type—solid.
Payload: Warhead type—HE.
Remarks: Designed for use against naval targets.

ARGENTINA

PSR-1 (Army)

Type: Surface-to-surface (anti-tank)
Status: R&D
Frame: Length—3.8 ft. Launch weight—19.5 lbs.
Booster: Type—Solid (1).
Payload: Warhead type—HE.
Remarks: Can be launched by one man.

PAT-1 (Air Force)

Type: Air-to-surface
Status: R&D
Performance: Range—about 12 miles.
Frame: Length—about 11 ft. Diameter—about 1 ft. Launch weight—2310 lbs. Material (major)—steel.
Booster: Type—liquid. Propellant—oxygen and methanol.

A3H (Air Force and Navy)

Type: Air-to-surface
Status: Operational
Performance: Range—3.8 miles.
Frame: Length—about 3 ft. Diameter—about 4 in. Launch weight—48 lbs. Material (major)—steel.
Guidance: Type—free.
Booster: Type—solid.
Payload: Warhead type—HE.

SOVIET UNION

GOLEM I (Navy)

Type: Surface-to-surface
Status: Near operational
Performance: Range—400 miles; Altitude—125 miles.
Frame: Length—54 ft.; Weight 16½ tons gross; single stage.
Remarks: Developed from German World War II plans for a sea-going V-2 (A-3). Liquid-fueled, radio-inertial guided. Designed to be launched from a capsule towed by a submarine. Nuclear capability.

GOLEM II (Navy)

Type: Underwater-to-surface
Status: RD&T
Performance: Range—1200-1300 miles.
Frame: Length—nearly 60 ft.
Remarks: Advanced version of the Golem I with improvements adopted from the Army T-2. Probably radio-inertial guided, liquid fueled. Nuclear capability.

GOLEM III (Navy)

Type: Underwater-to-air, surface-to-air
Status: Operational on surface vessels
Performance: Range—10 miles.
Frame: Length—15 to 20 ft.; Diameter—20 in.
Remarks: Solid-fueled, infrared-guided. Designed to give both submarines and surface ships anti-aircraft protection.

GOLEM IV (Navy)

Type: Surface-to-air
Status: Operational on surface vessels
Performance: Range—45 miles.
Remarks: A new missile, radar-guided and solid-fueled. May also be converted to submarine use.

M-2'S IN RED SQUARE

T-5B

T-1 (Army)

Type: Surface-to-surface
Status: Operational
Performance: Range—600-775 miles
Frame: Length—50 ft.; Weight—19 tons gross; single stage
Remarks: Mobile IRBM. LOX/hyrocarbon fueled booster generates 77,000 lbs. thrust. Radio-guided. Nuclear capability.

T-2 (Army)

Type: Surface-to-surface
Status: Operational
Performance: Range—1300-1500 miles; Speed—5000 m.p.h.
Frame: Length—between 85 and 91 ft.; Weight—55 tons; two stages.
Remarks: Liquid-fueled, 80,000 lb. thrust booster. The T-2 reportedly was the first Soviet rocket used to test an H-bomb warhead. Fired from Central Russia, the warhead was exploded at 120,000 ft. near Bennet Island in the Arctic.

T-3 (Air Force)

Type: Surface-to-surface
Status: Operational
Performance: Range—5000 miles; Speed—15,000 m.p.h.; Apogee—280 miles.
Frame: Two stages.
Remarks: Liquid-fueled with booster developing 500,000 lbs. thrust. Radio-inertial-guided. HE or nuclear warhead. Russia reportedly produced 50 T-3's in 1959 and has capability to build 1200 by the end of 1963.

T-3A (Army)

Type: Surface-to-surface ICBM
Status: Operational
Performance: Range (Model A)—6000 miles; Range (Model B)—7500 miles; Speed—15,000 m.p.h.
Frame: Model A—2 stages; Model B—3 stages.
Powerplant: Liquid-fueled. Model A first stage—525,000 lbs. of thrust; Model B first stage—700,000 lbs. of thrust.
Remarks: Production of the Model A is believed to have ceased in recent months in favor of the advanced version. Original production plans reportedly called for an equal number of T-3A Model A's and T-3's. The new booster stage on the Model B is believed to be a prototype for one used in the T-4A antipodal missile. Nuclear warhead.

T-4A (Air Force)

Type: Surface-to-surface antipodal missile
Status: Advanced RDT&E
Performance: Range—10,000 miles; Apogee—186.3 miles; Speed—13,660/m.p.h.
Frame: Length—121.02 ft.; Wing span—65.6 ft.; Max. Diameter—6.88 ft.; Launch weight—115 tons.
Powerplant: First stage has 3 LOX/kerosene engines developing 360,000 lbs. thrust.
Remarks: Catapulted from rail sled. Payload—2350 to 3100 lbs. This is the Soviet counterpart of the U.S. Dyna-Soar boost-glide bomber, stemming from the German Saenger-Bredt design conceived in World War II.

T-33 (Army)

Type: Surface-to-surface ICBM
Remarks: A new missile. No other details available.

T-4 (Army)

Type: Surface-to-surface IRBM
Status: Experimental
Performance: Range—1000 miles.
Powerplant: Two stages, both liquid-fueled.
Frame: Length—53 ft.
Remarks: 1800-lb. payload may be either nuclear or HE. Some of its configurations are believed to be worked into upper stages of the T-4A.

T-5 (Army)

Type: Surface-to-surface
Status: Operational with Red Army in Eastern Europe
Performance: Range—50-100 miles.
Frame: Length—about 36 ft.; 3 stages (advanced version may have 4 stages).
Powerplant: Solid-fueled.
Remarks: Designed for firing from multiple launchers for blitz-type saturation of target. HE or small nuclear warhead.

T-5A (Army)

Type: Surface-to-surface IRBM
Status: Operational
Remarks: Few details are available. Believed to be solid-fueled and guided.

T-5B (Army)

Type: Surface-to-surface
Status: Operational (but out of production)
Performance: Range—15-25 miles
Frame: Length—31 ft.; Diameter—3 ft.; Weight—6000 lbs.
Remarks: Similar to the U.S. Honest John. Launched from tracked vehicle. Unguided. Carries HE and possibly a nuclear warhead.

T-6 (Army)

Type: Surface-to-air
Status: Operational
Performance: Range — 20-25 miles; Speed — 1500 mph; Ceiling—about 60,000 ft.
Frame: 2 stages
Warhead: HE with proximity fuze.
Powerplant: Solid fueled with cluster of 4 solid boosters.
Remarks: Fired from multiple launcher. An advanced version, the T-6A, is radar guided and believed to be operational.

T-7A (Army)

Type: Surface-to-surface
Status: Operational
Performance: Range—50 to 90 miles; Speed—Mach 5; radio command guidance.
Frame: Length—30 ft.; Diameter—2.5 ft.; Weight—about 10,000 lbs.
Powerplant: Solid fueled
Warhead: HE
Remarks: Has controllable rear fins.

T-8 (Army-Air Force)

Type: Surface-to-air (also air-to-air)
Status: Operational
Performance: Range—15 to 25 miles; Speed—Mach 2.5
Frame: Length — 13 ft.; two stages
Powerplant: First stage is cluster of two solid fueled boosters, second stage is liquid fueled.
Warhead: HE with proximity fuze

T-7A

M-100A (Air Force)

Type: Air-to-air
Status: Operational
Performance: Range—3½ miles; Speed—Mach 2.5
Remarks: Solid-fueled, semi-active radio-radar command guidance.

ME-IGOR (Army)

Type: Anti-tank
Frame: Length—24 in.; Diameter—3 in.
Remarks: Solid-fueled. Fired from bazooka tube. Was operational, but probably used now only for training.

J-3 (Navy and Army)

Type: Surface-to-surface
Status: Operational with the Red Army and at least 7 Baltic fleet cruisers.
Performance: Range—450-600 miles; Speed—supersonic.
Frame: Length—36 ft.
Remarks: Booster is cluster of 4 solid-fuel rockets; ramjet sustainer. Guidance presumably is beam-riding or programed. Nuclear capability.

RS-82, RS-132, RS-132A (Air Force)

Type: Air-to-air
Frame: Length—unavailable; Diameter—5.2 in.
Remarks: Aircraft version of the GVAI. Used for training.

M-2 (Army-Navy)

Type: Anti-aircraft
Status: Operational with ground defense forces and aboard Baltic Sea cruisers.
Performance: Speed—Mach 2.
Frame: Length—about 25 ft.; 2 stages.
Remarks: Solid-fueled. Infrared, radar, or both used as guidance.

GVAI'S ON PARADE

GVAI (Army)

Type: Barrage rocket
Remarks: Multiple-tube launcher, fired in salvoes. May be phased out for more advanced versions.

KCAT-25 (Army)

Type: Anti-tank
Remarks: Never exhibited, believed to be operational.

KOMET I (Navy—CH 17 Army)

Type: Surface-to-surface
Performance: Range—100 miles; Speed—3000 m.p.h.
Remarks: Solid-fueled, the CH17 is reported to be operational with the Red Army. A crash program is underway to put the Comet I into service aboard submarines and surface ships. HE and nuclear warheads.

KOMET II (Navy—CH 18 Army)

Type: Surface-to-surface
Performance: Range—600 miles.
Remarks: Operational with the Red Army and from a surface vessel in calm waters. Crash program in progress with ship motion simulator equipment; R&D for submarines. Solid-fueled, nuclear warhead.

KOMET D (Air Force)

Type: Air-to-surface standoff
Status: In development and test
Performance: Range—55 miles.
Frame: Length—33.5 ft.; Diameter—about 4 ft.
Remarks: An equivalent to the British Avro, the turbojet-propelled missile may have beam-riding guidance. Warhead can be either nuclear or HE.

RELIABILITY...

every missile must count. A wasted firing due to a minor-part malfunction results in appalling losses in time and money. Combat condition failures are even more disastrous. Vitro Laboratories, under contract with the U. S. Navy Bureau of Ships, has developed advanced mathematical approaches to make reliability a predictable feature of design. Over a thirty month testing period predicted failures correlated strikingly with actual results. Tested equipment included radars, radar repeaters, radio transmitters and receivers, and radio terminal equipment. Reliability is another reason why Vitro is a leading name in systems engineering today.

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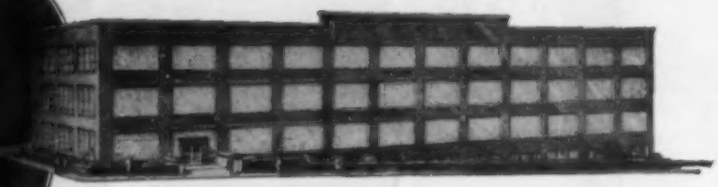

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Our instruments, 40 to 30,000 cycles, are used extensively by industry and on government projects where enduring accuracy and maximum durability are required. Your inquiries on related products are invited.

PRECISION FORK OSCILLATOR UNITS

TYPE 2003

Size 1½" dia. x 4½" H. Wght. 8 oz.

Frequencies: 200 to 4000 cycles

Accuracies:—
Type 2003 (±.02% at —65° to 85°C)
Type R2003 (±.002% at 15° to 35°C)
Type W2003 (±.005% at —65° to 85°C)

Double triode and 5 pigtail parts required.

Input, Tube heater voltage and B voltage

Output, approx. 5V into 200,000 ohms

TYPE 2007-6

TRANSISTORIZED, Silicon Type
Size 1½" dia. x 3½" H. Wght. 7 ozs.

Frequencies: 360 to 1000 cycles

Accuracies:
2007-6 (± .02% at —50° to + 85°C
R2007-6 (±.002% at +15° to + 35°C
W2007-6 (±.005% at —65° to + 85°C

Input: 10 to 30 Volts, D. C., at 6 ma.

Output: Multitap, 75 to 100,000 ohms

TYPE 2001-2

Size 3¾" x 4½" x 6" H., Wght. 26 oz.

Frequencies: 200 to 3000 cycles

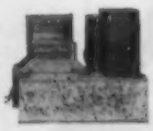
Accuracy: ±.001% at 20° to 30°C

Output: 5V. at 250,000 ohms

Input: Heater voltage, 6.3 - 12 - 28

B voltage, 100 to 300 V., at 5 to 10 ma.

ACCESSORY UNITS FOR 2001-2



L—For low frequencies multi-vibrator type, 40-200 cy.

D—For low frequencies counter type, 40-200 cy.

H—For high freqs, up to 30 KC.

M—Power Amplifier, 2W output.

P—Power supply.

PRECISION FREQUENCY STANDARDS

TYPE 2005A

Size 8" x 8" x 7¼" High
Weight, 14 lbs.

Frequencies:
50 to 400 cycles (Specify)

Accuracy:
±.001% from 20° to 30°C

Output, 10 Watts at 115V

Input, 115V. (50 to 400 cy.)

TYPE 2121A

Size
8¾" x 19" panel
Weight, 25 lbs.

Output: 115V
60 cycles, 10 Watt

Accuracy:
±.001% 20° to 30°C

Input,
115V (50 to 400 cy.)

TYPE 2111C

Size, with cover
10" x 17" x 9" H.
Panel model
10" x 19" x 8¾" H.
Weight, 25 lbs.

Frequencies: 50 to 1000 cy.

Accuracy:
(±.002% at 15° to 35°C)

Output: 115V, 75W.

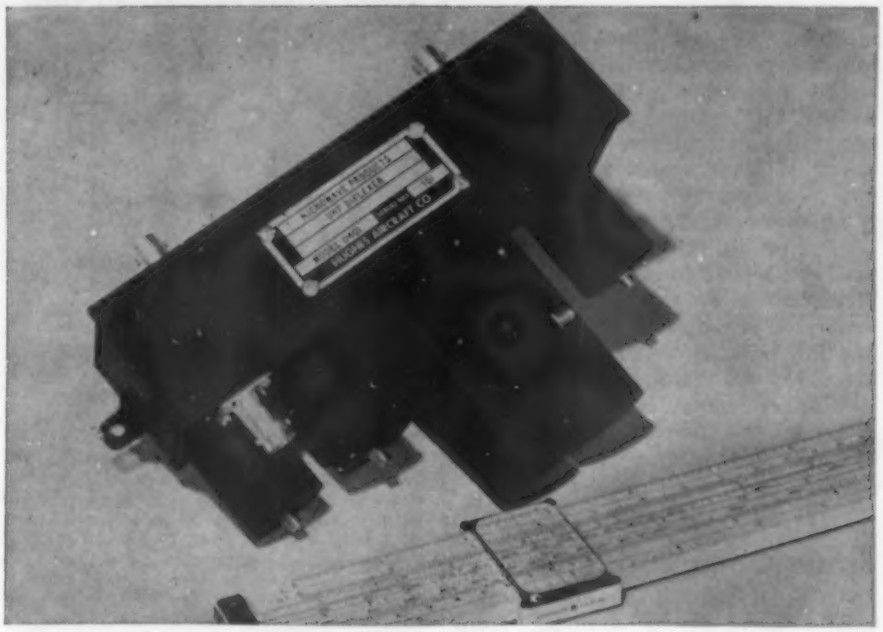
Input: 115V, 50 to 75 cy.

WHEN REQUESTING INFORMATION, PLEASE SPECIFY TYPE NUMBER

ATP

American Time Products Inc.
61-20 Woodside Avenue
Woodside 77, N. Y.

Circle No. 74 on Subscriber Service Card.



UHF Missile Diplexer

A lightweight UHF diplexer has been developed by Hughes Aircraft Co.

Known as Hughes Model U401, the diplexer permits a 100-watt transmitter and sensitive receiver to be operated simultaneously with a single antenna in the 225-400 MC band. With the transmitting frequency separated by less than ten per cent from the receiving frequency, isolation in excess of 100 db is provided in the receiving circuits, the announcement said.

To conserve transmitter power, the insertion loss between transmitter and antenna is only 0.2 db with a VSWR of 1.1. Design is such that no operational interaction between receiver and transmitter is experienced.

The unit consists of a special combining circuit together with a bridged-T network and a π– section filter on the receiving side. The assembly, which weighs less than one pound, has successfully withstood accelerations up to 150 g as well as other tests applicable to high-altitude rocket and missile environments.

Circle No. 225 on Subscriber Service Card.

APU Automatic Battery

Extremely high current output is featured in a silver-zinc primary battery designed for use in missile and space vehicle auxiliary power units by Cook Batteries. The battery is automatically activated by a reliable solid-propellant gas mechanism which has only one moving part.

The Model P80A provides 200 amps at 28 v. Maximum current is 400 amps, and discharge time is 1.8 min. An extremely efficient cell is used to provide high rate of discharge.

Circle No. 226 on Subscriber Service Card.

Printed Coax Mixer

Premier Instrument Corp. is producing a printed circuit broadband coax mixer which utilizes a replaceable printed circuit diode. The PC-Mix is a compact, low noise figure mixer with local oscillator level adjustment. The PC-Mix is capable of withstanding severe vibration and shock and is available in frequency ranges of 250 mc to 8000 mc in five basic units.

Circle No. 227 on Subscriber Service Card.

Linear Potentiometer

The Computer Instruments Corp. has added Model 111 Linear Motion Potentiometer to their present line of precision film components.

This potentiometer, designed for operation with an AC or DC input, provides, without amplification, outputs as great as 350 volts/inch of displacement.

The capability of the Model 111 to detect a motion as small as 0.000005 in., coupled with its life rating of up to 30,000,000 strokes, depending on circuitry, will make it of prime interest to those involved in the design of programed machine tools or other devices requiring precise knowledge of linear position.

Circle No. 228 on Subscriber Service Card.

Thermal Switch

Hermetically-sealed by employing a ceramic seal that is resistant to high temperatures, Control Products Inc. has designed a special purpose super-high temperature thermal switch which can be calibrated up to 1800°F. The switch is a probe type unit with a special cap that is locked in place after the final calibration has been made.

Contacts may be arranged for either close-on-rise or close-on-fall in temperature. Temperature tolerance is 6°F; temperature differential and repeatability for a given switch is ±1°F, while overshoot to 2200°F or an undershoot to −100°F can be tolerated without damage to the unit.

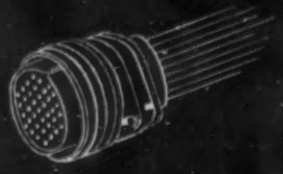
Circle No. 229 on Subscriber Service Card.

Swash-Plate Engines

A family of swash-plate engines and high-pressure pumps is available for general application from Clevite Ordnance.

The engines can be driven from any source of pressurized gas or vapor, including steam, cold gases such as

BENDIX
MS-R
ENVIRONMENT RESISTANT
Connectors



Bendix MS-R series are the small, lightweight, more efficient and compatible environment resisting class of connectors as specified in the latest version of MIL-C-5015.

Main joint and moisture barriers at solder weld ends have integral "O" rings. Grommet design of "slippery rubber" is sealing medium for individual wires. This provides easier wire threading and friction-free travel of grommet over wires.

Many other features are described in MS-R Bulletin. Send for your copy today, or

Call your
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AVNET•4180 Kettering Blvd., Dayton 39, Ohio- AX 8-1458
AVNET•2728 N. Mannheim Rd., Melrose Park, Ill.- GL 5-8160
AVNET•1262 N. Lawrence Sta. Rd., Sunnyvale, Cal.- RE 6-0300

Circle No. 77 on Subscriber Service Card.

. . . products & processes

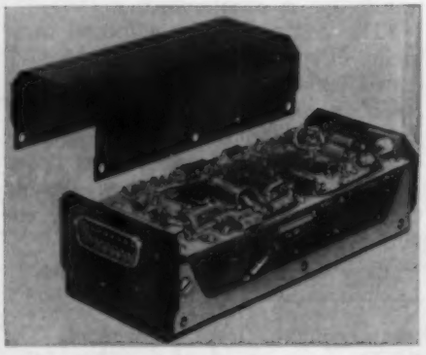
CO_2 and nitrogen, or solid and liquid rocket propellants. Engines deliver as much as 60% of input energy, and torque depends solely on pressure furnished. With input gas temperatures of 2150°F and pressures of 2000 psi, one hot-gas design delivers 100 horsepower at shaft speeds between 4000 and 5000 rpm. It weighs 30 lbs., and is 12 in. long and 6½ in. in diameter.

Pumps are available in wet and dry swash-plate design. Wet swash-plate models are suited to pumping a variety of noncorrosive liquids, including low-lubricity problem fluids like kerosene and hydraulic fluid. Dry swash-plate units are designed for pumping corrosive compounds such as nitric acid, hydrogen peroxide and hydrazine.

Circle No. 230 on Subscriber Service Card.

Strain Gage Oscillator

A transistorized strain-gage subcarrier oscillator is available from Electro-Mechanical Research, Inc. The instrument, designated the Model 179A, is intended for highly accurate conversion of strain-gage bridge signals into FM subcarrier signals on IRIG channels 1 to 14 and A.



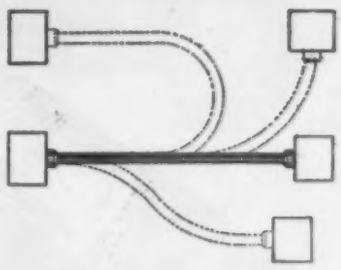
The subcarrier oscillator operates with a four-arm strain-gage bridge consisting of elements having 100 to 150 ohms resistance. There is no necessity for reactive balancing since internal oscillator circuitry automatically compensates for up to 1000 uuf capacitance across one arm.

Circle No. 231 on Subscriber Service Card.

Tapoffs, Splitters & Baluns

Blonder-Tongue Laboratories, Inc. has announced a complete line of advanced line splitters, tapoffs, and baluns. This advanced series of splitters and tapoffs can satisfy all installation requirements of large and small antenna systems in strong, intermediate and weak signal areas. A complete line of tapoffs and splitters is available for 75 ohm, 300 ohm, or mixed impedance systems.

FLEXIBLE SHAFTING OFFERS NEW FREEDOM OF DESIGN

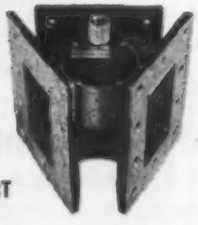


Before the innovation of Flexible Shafting, it was necessary to transmit power from a drive unit to its driven unit by means of a solid shaft which utilized expensive and cumbrous gearing. Today the Flexible Shaft alone provides a means of transferring this power from one unit to another by going around, over, and under obstacles. This allows you more space in your design, and eliminates the age old problem of having to have perfect alignment of the shaft and its drive or driven unit in order to make a connection. Flexible Shafts are simply curved towards the unit and connected by means of a ferrule, or an end fitting. If you have any application, now or in the future, which will require control from remote places, you owe it to yourself to write F. W. Stewart Corporation, 4311 Ravenswood Ave., Chicago 13, Illinois, for complete information on Circle Ess Flexible Shafting.

Circle No. 75 on Subscriber Service Card.

MICRO-MINIATURE
"DELTA"
WAVEGUIDE
SWITCH

A complete family of switches available in over 40 models



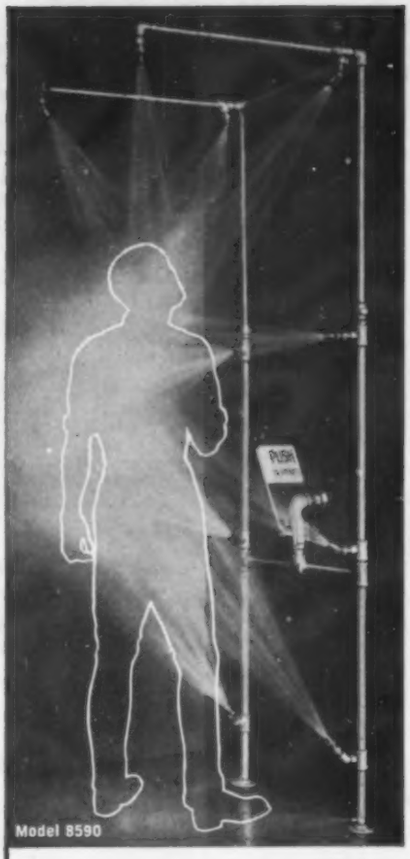
- EXTREMELY COMPACT & RUGGED
- WEIGHT 1.2 oz. to 4 lbs.
- HIGH SPEED OPERATION (.006 sec.)

- "FAIL-SAFE"
- FROM "L" TO "Q" BAND (2.6 to 50.0 KMC)
- AC or DC OPERATION
- REMOTELY CONTROLLED to switch a single waveguide input to either of two outputs.

WRITE FOR COMPLETE TECHNICAL INFORMATION

DON-LAN electronics, inc.
1101 olympic blvd., santa monica, calif.
division of Regan Industries, Inc.

Circle No. 76 on Subscriber Service Card.



Model 8590

contaminants off FAST!

HAWS SAFETY SHOWERS send torrents of rushing water from all angles – washing away dangerous irritants in a hurry!

Slap open the conspicuous "Push to Operate" valve. Hard-running streams from 10 *adjustable* nozzles drench victims in seconds.

You can depend on HAWS for the instant, *positive* first aid so vital until medical help arrives.

This "Safety on tap" can mean the difference between temporary irritation and permanent injury. Get the facts! Write for HAWS new safety catalog. Do it today!

Valve shown three-quarters open.

HAWS DRENCH SHOWERS

a product of

HAWS DRINKING FAUCET COMPANY
1443 Fourth Street • Berkeley 10, California

Export Dept. 19 Columbus Avenue San Francisco 11, California, U.S.A.

Circle No. 78 on Subscriber Service Card.

Coaxial cable may be plugged directly into a new type of solderless fitting and may be used with a quick disconnect. Flat 300 ohm transmission line need not be stripped, but is inserted directly into "no-strip" connectors and secured in place by tightening two screws.

Circle No. 232 on Subscriber Service Card.

Low Level Commutators

A line of low level, all solid-state electronic commutators for use in severe missile environments is available from General Devices, Inc.

Designed for airborne sampling of low level differential instruments such as strain gauges and thermocouples, the units contain up to 90 differential channels in high density packages. The 30 channel unit weighs only 2.5 oz. and is less than 1 in. in volume per channel. In addition, the units contain all necessary power converters and programing circuitry.

Circle No. 233 on Subscriber Service Card.

Miniature Torch

A miniature torch which uses gas or acetylene to produce intense pinpoint flames for delicate and close tolerance work is now available from Microchemical Specialties Co.

The Misco torch is only 7 inches long from tip to gas connection and weighs just three ounces. It features finger tip mixer controls for fine adjustment of flame and is furnished with three tips, .008″, .015″, and .020″ bore diameter. Other tips ranging from .004″ to .030″ are available.

Circle No. 234 on Subscriber Service Card.

Vibration Tester

A simplified portable vibration tester for quality control analysis which can be operated by factory personnel is being marketed by Rototest Laboratories.

In addition to its portability and low initial cost, other features of Rotocon (R) are: low operating and main-

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☐ Kindly send me STANPAT literature and samples. Dept. 13

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Title_____
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Address_____

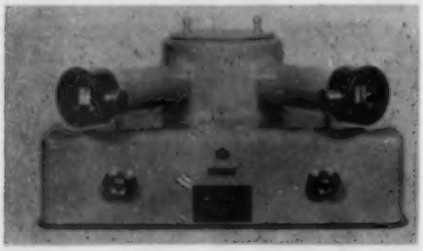
Circle No. 79 on Subscriber Service Card.

tenance, excellent sound proofing, and simple data take-off. In operation there is less than 75 db of noise measured six feet away from the machine. The tester provides a fundamental output vibration at 50 cps and overtones at predetermined multiples.

Circle No. 235 on Subscriber Service Card.

Scanning Monochromator

A McPherson Model 235 is a 50cm vacuum ultraviolet scanning monochromator that guarantees a vacuum of better than 1 x 10^{-5}mm Hg is available from McPherson Instruments Corp. This compact table model



consists of a vacuum chamber, bilateral entrance and exit slits, a 50cm radius of curvature grating with 600 lines per millimeter, and a screw-driven scanning mechanism with 12 reversible speeds. A counter reads actual wavelengths in Angstrom units from Central Image through 6000A, and is accurate to ± 1A.

Circle No. 236 on Subscriber Service Card.

Copper Clad Laminates

A complete line of thin copper clad laminates is available from the Plastic Products Division of International Resistance Co.

The materials involved include the complete range of insulation, from vinyl and polyethylene to teflon and glass reinforced teflon.

Available now is 1 or 2 ounce copper bonded to 0.005 Kel-F, 0.005 teflon-FEP, 0.007 teflon-glass cloth, 0.005 linear polyethylene and 0.006 mylar.

Circle No. 237 on Subscriber Service Card.

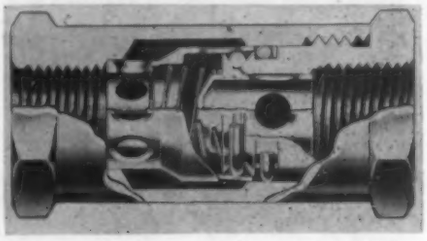
Environmental Room

Labline, Inc. is marketing a line of walk-in environmental rooms with two temperature ranges: ambient to 140°F and 0° to 140°F. Accuracy is maintained within plus-minus 1°F. The test rooms are constructed in convenient panel form, shipped knocked down to permit easy access through narrow doorways.

Circle No. 238 on Subscriber Service Card.

Surge Flow O-Ring

An engineering development positively assures O-ring reliability against high pressure split-second surge flows, in the latest from Circle Seal Products. Faster acting solenoid and other rapidly actuated valves in higher pressure systems have created new problems which the Circle Seal 200 Series Check Valve has successfully eliminated. Fool-proof



O-ring retention is assured by an ingenious cage device which positively restrains the O-ring from washout. Heavier, more rugged construction of the body provides additional protection against abuse and failure.

Circle No. 239 on Subscriber Service Card.

Four Pin Holders

Supplementing its line of three-pin transistor holders, Sealectro Corp. is producing a four-pin transistor holder. Designated as TC-400T, the new hold-

MEASURE
Dynamic High Pressures

with
Technoproducts
PT-3 TRANSDUCER

A rugged gauge for measuring large transient forces or pressures, the PT-3 Transducer has been proven by years of use in ordnance and ballistic testing. Applications include measurement of pressure vs. time in guns, gas cartridges, and explosive actuated devices; and combustion, ignition, and shock-wave research. Pressure ranges from 0-10,000 to 0-100,000 psi.

Technoproducts
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Circle No. 80 on Subscriber Service Card.

MISSILE
SYSTEMS
ANALYSIS

RELIABILITY ANALYSES and EVALUATIONS

INTEGRATED SYSTEMS STUDIES

Consulting and contractual services are offered in the major areas of missile systems analysis. Special emphasis is given to reliability analyses within the framework of over-all systems concepts. Inquiries are invited.

McAllister and Associates, Inc.
203-205 Truman, N.E.
Albuquerque, New Mexico

Circle No. 81 on Subscriber Service Card.

ers feature the "Press-Fit" technique which permits fast and economical chassis insertions. Both the TC-200T (3 pin-holder) and TC-400T (four-pin holder) are constructed with extra-long terminals which act as a heat sink and permit soldering of transistors in place with greatly reduced danger of damage to the transistor elements.

Circle No. 240 on Subscriber Service Card.

High Pressure Regulators

Grove Valve and Regulator Co. has designed a new line of small volume high pressure regulators.

The regulators, or "loaders," can handle a wide range of pressures. The interior construction is highly resistant to corrosion. All metal parts in contact with line fluid are stainless steel including the filter. The regulators are designed using a minimum number of parts to reduce maintenance problems and boost repeatable accuracy.

Circle No. 241 on Subscriber Service Card.

Transistor Welder

An automatic transistor welder has been developed by National Electric Welding Machines Co.

A 3 ft. x 4 ft. table, 32-inches high, forms the top of the unit's base and is designed specifically to accommodate a standard dry box. An operator, seated at the console and hand-loading a six-station dial, can produce 2000 transistors an hour, according to National Electric engineers.

Circle No. 242 on Subscriber Service Card.

Fast Microwave Switch

A fast acting, high-power microwave switch that can be closed in tenths of a microsecond has been developed by Electric Products Inc.

The new microwave switch uses a gas discharge, similar to that in a thyratron, to create a fast acting and relatively high power switch for a microwave line. In addition to closing in tenths of a microsecond, the switch can be reopened in a few microseconds.

Circle No. 243 on Subscriber Service Card.

High Purity Gold

Gold, 99.999% pure, is available in powder and sheet form from High Purity Metals, Inc.

The gold offers semiconductor manufacturers excellent wetting to silicon at relatively low temperatures (in the order of 700°C). The gold exhibits high thermal conductivity and vapor pressure, along with superior resistance to corrosive acids.

Circle No. 244 on Subscriber Service Card.

Propellant Briefs from Callery Chemical Company

New fuel for Air Force by late summer—Callery is now modifying the Government-owned plant at Muskogee, Okla. to produce pentaborane under a new $9-million Air Force contract. Plant was originally built to produce high-energy boron fuels.

Pentaborane production begins late this summer for Air Force requirements only. At the outset, at least, no pentaborane will be available for commercial sales. Also worth noting: plant modification still maintains our capability for high-energy fuel production.

PENTABORANE (B_5H_9) Performance Data—Potential of pentaborane as a fuel is evident in its high heat of combustion—29,000 Btu/lb.—and its high specific impulse. Recent calculations yield the following shifting-equilibrium impulses for pentaborane:

Oxidizer	Is 1000/14 psia	Is 1000/.2 psia
OF_2	367	466
F_2	360	460
O_2	327	421
NF_3	326	413
H_2O_2	316	399
ClO_3F	306	391
N_2O_4	306	390
NO_2ClO_4*	302	389

*More about NO_2ClO_4, Nitronium Perchlorate, a new solid oxidizer, will appear in this column next month.

Pentaborane is soluble without reaction in saturated and aromatic hydrocarbons. May explode with oxygenated or halogenated compounds like acetone or carbon tetrachloride.

Pentaborane is compatible with all common metals, Saran, polyethylene, Kel-F, Viton A, asbestos, and graphite.

Write for Bulletin—Pentaborane C-1300.

Los Angeles office open for West Coast technical service — J. R. Perrin, new West Coast Representative for Callery, will serve fuel and propellant users in the Los Angeles area. His address is 17618 Ventura Boulevard, Encino, California. Telephone: State 4-9328.

In the Washington, D.C. area, contact Richard A. Carpenter, Room 709, DuPont Circle Building, 1346 Connecticut Avenue, N.W., ADams 4-4200.

For information or technical service: write Defense Products Dept., Callery Chemical Company, P.O. Box 11145, Pittsburgh 37, Penna.

Mr. J. R. Perrin
Manager, Western District
Defense Products Department
Callery Chemical Company

CALLERY
CALLERY CHEMICAL COMPANY

Circle No. 82 on Subscriber Service Card.

new literature

TEST AND SENSING GUIDE—Alden Products has published a Vest Pocket Guide and Wall Chart to help the design engineer choose the right test and sensing component. This chart contains complete specs on Alden panel lights, switches, fuseholders, test prods and jacks and molding materials.

Circle No. 200 on Subscriber Service Card.

BASICS IN THE MACHINING OF TEFLON—An informative 12-page booklet released by the Plastic Products Division of Raybestos-Manhattan contains R/M suggestions for stress relieving; tools and coolants to use; speeds and rates of feed; rakes, angles and clearances; burrs and chips; turning, boring, drilling, tapping, reaming, counterboring, grinding; fly-cutting; surface finishes; tolerances, etc.

Circle No. 201 on Subscriber Service Card.

STRAIN GAGES—A line of subminiature, free-filament wire strain gages, designed for accurate strain measurement on any test surface or material in a wide variety of applications including high temperature, are discussed in a 4-page, 2-color new product data sheet released by the Electronics & Instrumentation Division of Baldwin-Lima-Hamilton Corp. Product Data Sheet 4330 contains line drawings, graphs and tables to support the data and specifications concerning this strain gage, Type HT. Microminiature built-in thermocouples are also available if desired.

Circle No. 202 on Subscriber Service Card.

TRANSFEROBOT—USI Robodyne Division of U.S. Industries, Inc., has published literature describing its "TransfeRobot." It explains the concept of flexible and versatile automation equipment and how it is embodied in this member of USI Robodyne's family of automation products. The literature describes the design and operation of the "TransfeRobot" as well as the simple means of programing and set-up, which permits it to be switched from job to job in one-half hour.

Circle No. 203 on Subscriber Service Card.

CONTROL COMPONENTS—Over 2500 components for control of gas or liquid over a temperature range of –320° to 1500°F, and pressures to over 3500 psig are covered in a new catalog published by The Garrett Corp.'s AiResearch Manufacturing division. Major items available for aircraft, missile or process industry applications include: fuel control systems, pneumatic and electrical valves, actuators, air motors and thermostats.

Circle No. 204 on Subscriber Service Card.

ZIRCONIUM OXIDES—The Zirconium Corp. has available a well-illustrated four-page brochure on zirconium oxides and high-temperature materials. The brochure lists materials and describes the processes Zircoa uses in manufacturing their high-temperature refractories. Pictures showing plant facilities, standard and custom refractory shapes are included.

Circle No. 205 on Subscriber Service Card.

PRESSURE REGULATOR CATALOG—Now available from OPW-Jordan, an 8-page Catalog gives up-to-date information on the complete line of Sliding Gate Pressure Regulators. The brochure describes in detail the OPW-Jordan self-operated, pilot-operated, solenoid operated and back pressure Regulators.

Circle No. 206 on Subscriber Service Card.

HIGH ALUMINA TECHNICAL CERAMICS—Diamonite Products Manufacturing Co. has available a brochure covering data and the application of high alumina technical ceramics to the electronics industry. Off the shelf service for standard rods, tubes and cylinders are listed with prices in various quantities. The six-page brochure contains a chart of comparative properties of Diamonite materials for electronic applications. A graph of dielectric loss factors of Diamonite material on a comparative scale is also shown.

Circle No. 207 on Subscriber Service Card.

WIND TUNNEL DATA—How the National Aeronautics and Space Administration reduces high-speed wind tunnel data at their Langley Field, Va., test center is the subject of an application information bulletin just released by the Systems Division of Beckman Instruments, Inc. In addition to a description of the data system installation and its function, the bulletin includes system specifications, block diagram, operation explanation and photograph.

Circle No. 208 on Subscriber Service Card.

FACILITIES BROCHURE—A Research, Engineering, and Manufacturing Facilities brochure has been released here by the Gabriel Electronics Division of The Gabriel Company. The brochure depicts the new, ultramodern facilities at Millis and illustrates the utilitarian design of the structure for the engineer, research specialist, and for electronics component manufacturing.

Circle No. 209 on Subscriber Service Card.

Leitz
The NEW Concept in
AUTO-COLLIMATORS
• For checking angular deviations within 1/10 second of arc over an expanded range of 30 minutes.
• Short and compact design of 13" overall length, retaining 20" focal length by folded beam.
• 2¼" aperture of objective.
• Measurements in 2 planes by merely rotating eyepiece 90°.
• Range of focus 0-50 feet.
• Large assortment of accessories.
• Request catalog 85-3.
OPTO-METRIC TOOLS, INC.
137MR VARICK STREET, NEW YORK 13, N. Y.

Circle No. 83 on Subscriber Service Card.

NUCLEAR LAB INSTRUMENTS—A 64 page catalog of nuclear laboratory instruments and related accessories is now available from Tracerlab. The new "General Catalog F" contains complete descriptive information and specifications on all Tracerlab products for nuclear research, education and clinical applications. Among the instruments described are scalers, ratemeters, spectrometers, geiger, proportional, and liquid scintillation detectors, manual and automatic sample changers, data printers, high voltage power supplies, radiation research equipment, sample preparation and handling equipment, and personnel and safety protection equipment.

Circle No. 210 on Subscriber Service Card.

DIGITAL VOLTMETERS—A new 20-page, two-color bulletin on NLS SERIES 20 transistorized digital voltmeters, ratiometers and ohmmeters has been produced by Non-Linear Systems, Inc. The booklet covers the premium models in the NLS line. They include the M24 Multi-Purpose Instrument for measuring DC voltage, voltage ratio and resistance; the V24 Volt-Ratiometer for measuring DC voltage and voltage ratio; and the R24 Ratiometer for measuring DC voltage only.

Circle No. 211 on Subscriber Service Card.

INERT-GAS WELDING—A revised edition of Air Reduction's catalog on its complete line of manual, semi-automatic and automatic Heliwelding (Airco's tungsten-inert-gas welding process) equipment has just been published. The booklet also contains information on accessory equipment, tungsten electrodes, and filler wires used in conjunction with this welding process.

Circle No. 212 on Subscriber Service Card.

POTENTIOMETER TRANSDUCERS—A bulletin consisting of 4 pages filled with specification data for potentiometer transducers is available from H. E. Sostman & Co. Designed to serve as an assistance for the specifying engineer concerned with industrial instrumentation, the bulletin is thorough, yet concise in its treatment of transducer specifications as applied to pressure, motion, altitude, weight, flow, indicating, recording, systems and controlling.

Circle No. 213 on Subscriber Service Card.

FLUOROSCOPY—A new 4-page folder, describing Fluoroscopy with high-speed movies is available from Philips Electronic Instruments. The text discusses the new method for inspection of components and assemblies under actual operating conditions. The folder describes how units under test can be evaluated during functional conditions such as simulated high frequency vibration. Reliability diagnostic testing during preproduction evaluation and production non-destructive testing of critical components are also covered.

Circle No. 214 on Subscriber Service Card.

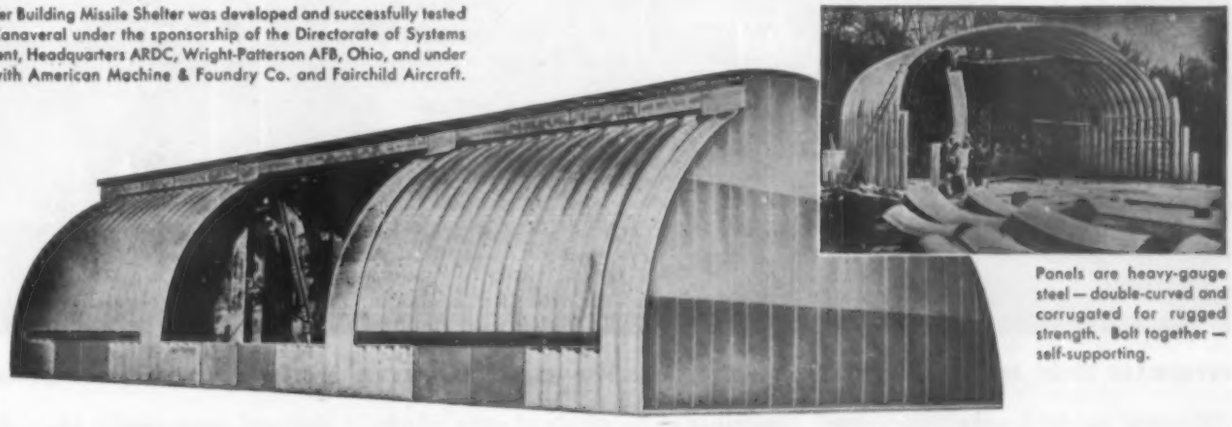
RARE EARTHS—Vitro Chemical Co. has issued a new brochure, containing complete technical information about various chemicals, metals and alloys of the rare earth group of elements, Thorium, scandium and yttrium. In addition to potential uses, it describes manufacture and lists detailed properties and chemical analysis of more than 50 products, several of which are now available for the first time on a commercial scale.

Circle No. 215 on Subscriber Service Card.

TELEMETER SIGNAL CONDITIONER CIRCUITS—Descriptions of the designs of signal conditioner units suitable for processing many types of outputs prior to transmission are included in this brochure by Texas Instruments, Inc. The more important designs, evaluated for missile use and which are available as off-the-shelf items are listed.

Circle No. 216 on Subscriber Service Card.

This Wonder Building Missile Shelter was developed and successfully tested at Cape Canaveral under the sponsorship of the Directorate of Systems Management, Headquarters ARDC, Wright-Patterson AFB, Ohio, and under contract with American Machine & Foundry Co. and Fairchild Aircraft.



Panels are heavy-gauge steel — double-curved and corrugated for rugged strength. Bolt together — self-supporting.

HOW WONDER BUILDING CAN SOLVE YOUR SHELTER PROBLEM

Three basic designs with unlimited adaptation to meet any shelter or storage need — that's Wonder Building versatility! You get a structure that fits *exactly* with no sacrifice in space, utility or cost.

Choose from straight sidewall, arch-type or wide-span "Truss-Skin" Roof Systems in widths up to 300 feet — lengths unlimited. Each provides clear-span, unobstructed interiors . . . each assembles on location, can be modified, expanded—dismantled and reassembled with a minimum of time and effort.

Wonder Building® patented construction technique means simple, fast erection—even with unskilled labor. Rugged steel panels provide a tight, weather and wind-proof structure. Upkeep is negligible—no painting, no roofing to maintain.

See your Wonder Building distributor, or mail the attached coupon.

Listed in Sweet's Architectural File Index No. 2b/Wo.

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Wonder Building

wonder building corporation of america
Government Products Division, Dept. EE760,
30 N. LaSalle Street, Chicago 2, Illinois

Please send me literature and engineering specifications on Wonder Building Structures. I am primarily interested in

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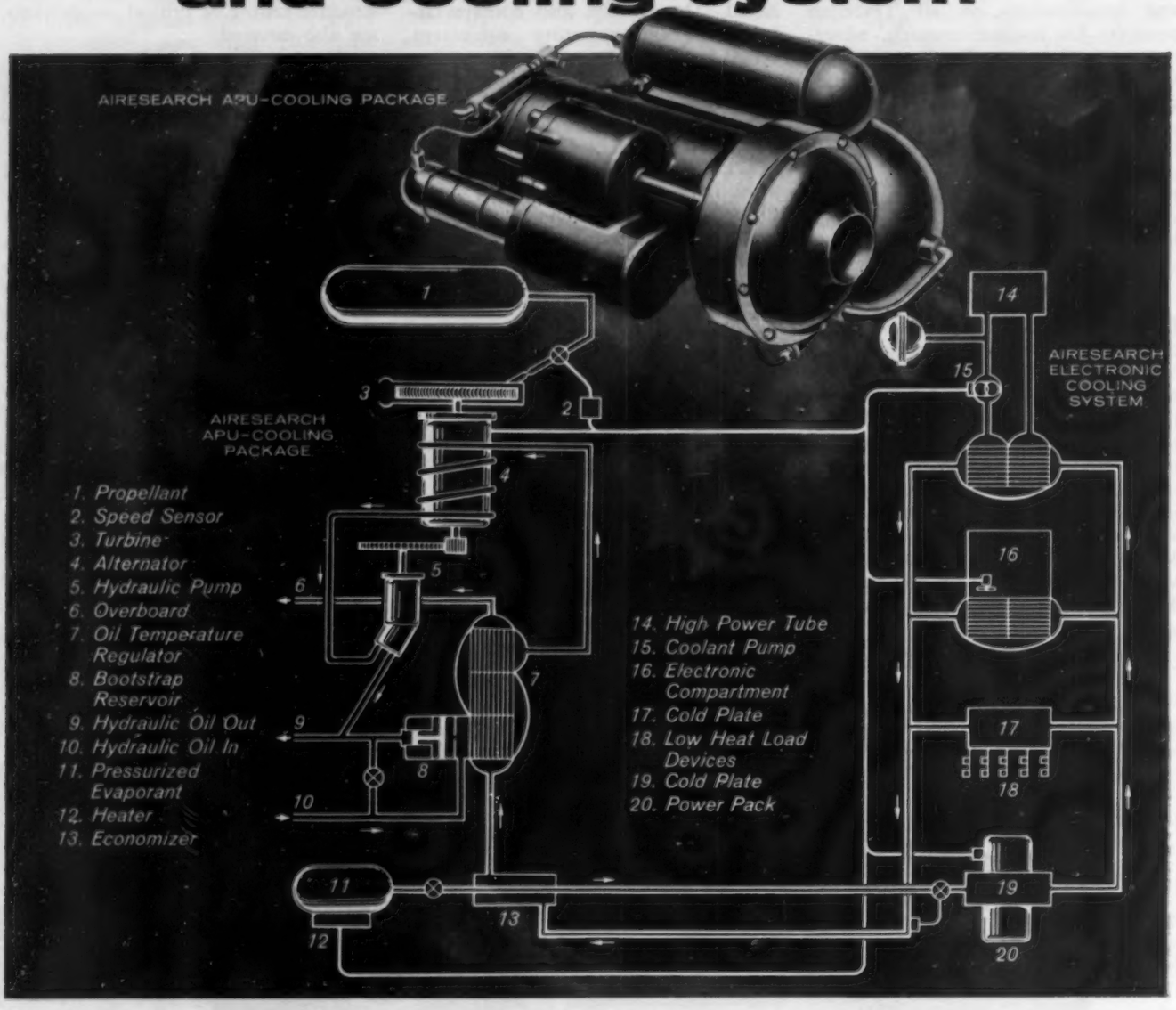
Address.....

City.....Zone....State.....

Circle No. 84 on Subscriber Service Card.

Integrated accessory power and cooling system



meets the most advanced missile and space vehicle requirements

AiResearch has developed a *single* system package for missiles and space vehicles to meet increasing accessory power and cooling load requirements in the face of decreasing size and weight allowances.

This integrated accessory power and cooling system supplies hydraulic power for actuating systems, 3200 or 400 cycle three-phase electric power for guidance and control, and at the same time provides cooling both for the APU and all electronic equipment operating in the missile or space vehicle.

The cooling system in the example shown here uses liquid ammonia as the expendable evaporant, and each heat load area has a separate temperature control valve. Alternator and controls, turbine assembly and APU liquid propellant fuel tank are patterned after operationally proven components.

World leader in the design and manufacture of cooling and accessory power systems, AiResearch has delivered more missile APUs than any other company, and is the leader in advanced electronic cooling systems for aircraft, missiles and spacecraft.

AiResearch design and manufacturing experience in these two fields includes: liquid and solid propellant APUs; hydraulic and hot gas actuators and control systems; 3200 and 400 cycle alternators; cold plates; expendable and closed cycle gas and liquid cooling systems; cryogenic cooling systems.

Please direct inquiries to Los Angeles.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems and Components for: AIRCRAFT, MISSILE, SPACECRAFT, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

Circle No. 85 on Subscriber Service Card.

names in the news

CHEN

RABI

COTTON

GREYSON

KULLAS

B. S. Chen: Former assistant director of engineering at the space communications division of Radiation, Inc., joins Dynatronics, Inc. as manager of the design engineering division.

Dr. Isidor I. Rabi: Chairman of the President's Science Advisory Committee for the past 15 years and advisor to the Atomic Energy Commission and the Departments of State and Defense, named technical consultant to Loral Electronics Corp.

H. C. Cotton: Former sales manager for the Army's *Pershing* program at The Martin Co.'s Missile and Electronics Division, appointed to the newly created post of manager-advanced systems at Ryan Aeronautical Co.

William L. Greyson: Former director of research and development at Hitemp Wires, Inc., joins Dilectrix Corp. as director of research and development and chief of a "New Horizon" design and development department.

A. J. Kullas: Named technical director of The Martin Co.'s rocket booster portion of the Air Force *Dyna-Soar* program. He joined the firm in 1940 as a structures analyst and subsequently served as structures manager, chief engineer, manager of flight vehicle design engineering and manager of technical development.

Dr. Solomon L. Miller: Elected head of the research section of the research and development department of Rheem Semiconductor Corp. Was previously manager of the device analysis section in the semiconductor research department of IBM's Research Laboratory and prior to that a research physicist at Bell Telephone Laboratories working on semiconductor devices.

William Fitzwater, Jr.: Former senior design specialist with North American Aviation's Autonetics Division, joins Epsco-West as senior design specialist.

Arthur G. Wimer, Jr.: Named to the newly established position of chief scientist for the Air Research and Development Command (ARDC), the top civilian advisor to **General Bernard Schriever.**

Thomas LeSueur Hardy: Appointed senior systems engineer to head Arnoux Corp.'s new Huntsville, Ala., office. Previously served as design engineer for Martin-Orlando and as field engineer for both Col-Ins-Co., Inc. and Murphy Cota Co.

Myron A. Tracy: Manager of The Garrett Corp.'s Washington sales office, appointed manager of military relations responsible for conducting all prime military sales and contract negotiations for Garrett and its AiResearch Manufacturing divisions.

Peter W. Cummins: Supervisor of market research for the Continental-Diamond Fibre Corp., a subsidiary of The Budd Co., promoted to manager of product planning and market research.

Dr. Peter Fortescue: Who will continue to act as chief research and development engineer for the General Atomic Division of General Dynamics Corp., appointed chief research and development engineer of the newly organized General Atomic Europe.

Prof. Thomas Gold: Chairman of Cornell University's department of astronomy and director of its center for radiophysics and space research, elected special consultant to the National Research Corp. on projects relating to the direct conversion of solar energy to electric power.

Emory W. Farr: Special projects engineer for Statham Instruments, Inc., and **Joseph C. Sanchez,** lead engineer in the Structures Laboratory of North American Aviation, join Electro-Optical Systems, Inc., as project engineers in the Transducer Laboratory of the Solid State Division.

Donald P. Vaughan: Former director of sales for the Trimpot Division of Bourns, Inc., joins Spectrol Electronics Corp. as marketing manager.

Joseph Robert Lewis: Appointed director of engineering for the Sierra Electronic Division of Philco Corp.

Sam Cravitt: Joins Del Electronics Corp. as a senior research project engineer. Was formerly with Farrand Optical Co. as a research project engineer working in the field of infrared instrumentation, components, fire control and navigation systems.

F. Robert Walker: Former field sales manager of closed circuit TV equipment with General Electric, joins Gulton Industries, Inc. in the newly created position of manager of marketing.

Dr. Bernhard H. Goethert: Director of Engineering for ARO, Inc., contract operator for the USAF's Arnold Engineering Development Center, elected a member of a special scientific panel in the North Atlantic Treaty Organization's Advisory Group for Aeronautical Research and Development.

Charles E. Hunter: Special assistant to the president of Thiokol Chemical Corp., has temporarily been assigned to the West Coast area in connection with the corporation's rocket activities.

Louis H. Aricson: President and general manager of Daystrom, Inc.'s Transicoil Division, appointed vice president, human relations, in charge of executive development, industrial relations, public relations and advertising. He succeeds **L. E. Minkel,** who resigned to join Studebaker-Packard Corp.

Theodore Grant: Elected western office manager for the Aerospace Industries Association in Los Angeles, replacing **Capt. Leland D. Webb (USN-ret.)** retiring.

C. Wesley La Blanc: Former assistant to the president of the Magnavox Co., joins the United Industrial Corp. as assistant to the president.

Philip L. Sommer: Formerly with Chrysler Corp., where he was responsible for customer relations activities in Washington, appointed a Washington representative for Boeing Airplane Co.

John Mihalic: A vice president of Avco Corp. and president of its Nashville Div., named president of the Crosley Div., succeeding **F. C. Reith,** deceased.

Fred L. Schwab: Former sales manager of Phillips Control, appointed sales manager of Relay Sales, Inc.

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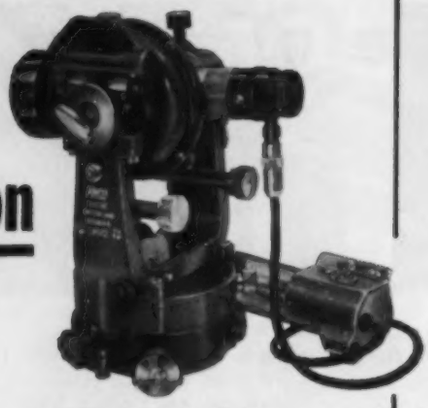

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$1,400,000—Melpar, Inc., Falls Church, Va., for target detection devices and systems.

$304,415—Stanford Research Institute, Menlo Park, Calif., for design, development and manufacture of a parabolic antenna.

$82,211—Convair Division of General Dynamics Corp., San Diego, for design and development of a magnetic tape system.

$68,984—Lockheed Electronics Co., Plainfield, N.J., for design and construction of masts and stabilized platform.

$55,000—Microwave Electronics Corp., Palo Alto, Calif., for research on traveling wave amplifiers.

$31,560—AiResearch Mfg. Co. of Arizona, for research on the matching of propulsion systems to the ground effect machine.

$25,815—Dage Television of Thompson Ramo Wooldridge, Inc., Michigan City, Ind., for research on *ARCAS* videosonde.

AIR FORCE

Cook Technological Center, Morton Grove, Ill., for study, design and fabrication of a supersonic parachute sled test vehicle. Amount not disclosed.

$247,000,000—Boeing Airplane Co., for research and development connected with the hardened and dispersed concept in which the solid-propellant *Minuteman* will be placed in blast-resistant underground silos, ready for launching.

$15,625,000—General Electric Co.'s Heavy Military Electronics Dept., for AN/FPS-24 frequency diversity search radars.

$5,279,088—RCA Service Co., Division of RCA, for the complete management and operation of "White Alice" project.

$1,000,000—Space Electronics Corp., for fabrication of the electronic systems for the *AbleStar* upper stage booster. Subcontract from Aerojet-General.

$154,000—General Precision, Inc.'s Kearfott Div., Little Falls, N.J., for necessary personnel, facilities, materials and supplies to conduct an engineering study on the techniques and applications of recursive logic.

$136,000—General Instrument Corp.'s Advanced Development Laboratory, Westbury, N.Y., for development of a new type of airborne "telemetry" radio transmitter which will automatically beam back to earth data on conditions of the upper atmosphere.

$108,600—Lieb-Jackson, Inc., Columbus, Ohio, for fabrication, delivery and installation of a complete diffuser section and heat exchanger.

$100,000—The Martin Co., Baltimore, for providing a 15-year master plan of checkout systems for manned and unmanned weapons.

ARMY

Servomechanisms, Inc., Research Division, Goleta, Calif., for development and fabrication of a 560-watt thermoelectric generator. Amount not disclosed.

Piasecki Aircraft Corp., Philadelphia, has received a subcontract for the complete airframe manufacture of a new missile. Amount not disclosed.

Redstone Machine & Tool Corp., Huntsville, for fabrication and assembly of missile components, tooling and equipment—*Saturn*. Amount not disclosed.

$7,199,262—Convair, Division of General Dynamics, Pomona, for development of the *Mauler* missile system. (Two contracts.)

$6,597,044—Western Electric Co., Inc., New York City, for engineering services on the *Nike-Hercules*.

$4,069,000—Western Electric Co., Inc., New York City, for components of the Missile Monitor system.

$3,393,601—General Electric's Missile Production Section, for safing, arming and fuzing systems for advanced surface-to-surface missiles. (Two contracts.)

$3,159,303—Sylvania Electric Products, Inc., Needham, Mass., for a large-scale mobile digital computer.

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$1,434,000—Morrison-Knudsen Co., Inc., Honolulu, for construction of a *Nike-Hercules* project, Oahu, Hawaii.

$1,160,000—Sylvania Electric Products, Inc.'s Electronic Defense Laboratories, Mountain View, Calif., for design, fabrication, installation and field support of specialized electronic warfare equipment.

$1,000,000—Hallamore Electronics, division of The Siegler Corp., for special test equipment for the *Titan*.

$620,187—Brown Engineering Co., Inc., Huntsville, Ala., for engineering and manufacturing services—*Saturn*.

$297,955—Edward R. Marden Corp., Brookline, Mass., for construction of additional facilities, satellite tracking station, New Boston, N.H.

$250,000—Temco Aircraft Corp., Dallas, for manufacture of aluminum outer shells for the guidance and warhead sections of the *Hawk*. Subcontract from **Raytheon Co.'s Missile Systems Div.**

$235,000—Lockheed Aircraft Corp., Marietta, Ga., for fabrication and assembly of miscellaneous components for *Saturn*.

$234,000—Century Tool Co., Camden, N.J., for electro-mechanical guided missile tool kit for *Hawk*.

$172,147—Parkhill-Goodloe Co., Jacksonville, Fla., for dredging a channel and turning basin to accommodate *Saturn* unloading facilities at Cape Canaveral.

$155,500—Rothwell Construction Co., Ltd., Honolulu, for construction of a *Nike-Hercules* maintenance shop.

$101,075—U.S. Amalgamated Constructors, Inc., Tampa, for construction of a 2800-sq.-ft. concrete frame and block building to house ground-air transmitter-receiver equipment at MacDill AFB.

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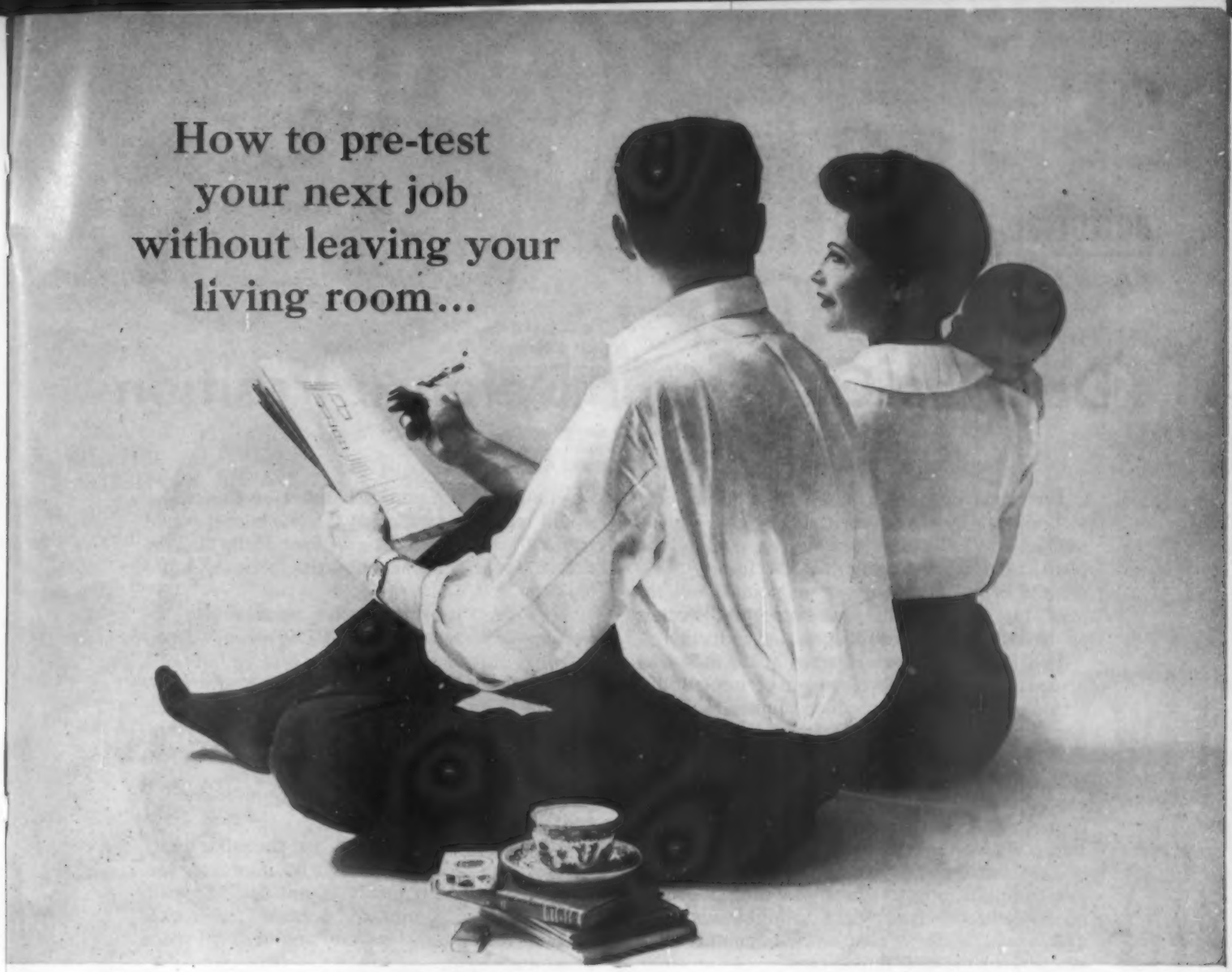

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editorial . . .

Douglas Gives Our Defense Position

For some time there has been a strong conviction that the Department of Defense should outline for the defense industry its policies and plans, as near as possible, for the future. Some months back, on this page, we pointed out the need for guidance in such important matters as diversification, consolidation and reduction.

In a recent statement directed at the industries responsible for the development of most of the nation's missile/space products, James H. Douglas, Deputy Secretary of Defense, has done just that. Although he hedges with cautious admissions that forecasting even a year or two ahead is subject to a considerable margin of error, the former Air Force Secretary plants several clear sign posts for the road ahead. Some of them are:

That for the big primes in the aircraft and missile/space industry there has been a decline of 50% in the floor space requirements since 1957—with a further contraction of another 50% probable in the next three years.

That the defense industry must be increasingly alert to the possibilities of foreign sales. While he did not specify, this is particularly true in the field of small missiles and rockets, both for military use and for space exploration.

That if consolidations and mergers become necessary to maintain skills and capacities, DOD will be interested in exploring the possibilities with industry.

Mr. Douglas pointed out that in formulating the '61 budget the Pentagon made it clear there was no bright prospect ahead that world tensions would relax, and indicated the '62 budget would reflect the same thinking. Specifically in the missile/space field, he listed the following probabilities:

That there are "persuasive reasons" for believing the missile-carrying B-70, or a weapon system with similar capabilities, will be built.

That the nuclear-powered aerial platform for both air-to-air and air-to-ground ballistic missiles will not be in the inventory for a number of years.

That missile expenditures in '62 seem likely to be about the same as '61, a program designed to give us an "immense mixed capability" by the end of calendar 1963.

Our present liquid missiles and the solids under development will be followed by improved versions or by "a new family of missiles," he said.

He saw a continuing demand for rocket boosters for both our military and our civil space programs.

And finally, Mr. Douglas forecast that the dollar volume of business, although perhaps changing in character and more widely spread, would continue to be "very large" in aviation products, missiles and space products.

While the Secretary's statement may contain little that is new or startling, it is an analytical summation of DOD thinking and attitude quite in keeping with Mr. Douglas' cautious but lucid approach to the problem. It is a paper the defense industry welcomes.

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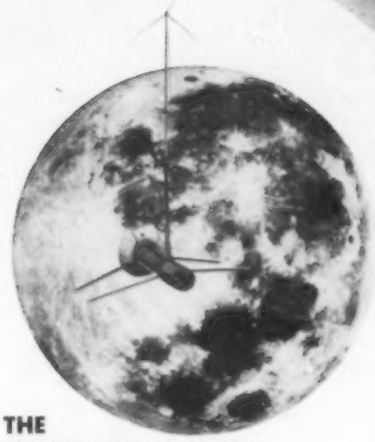

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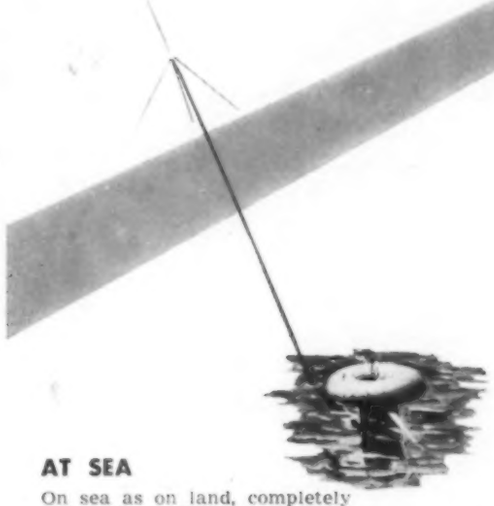

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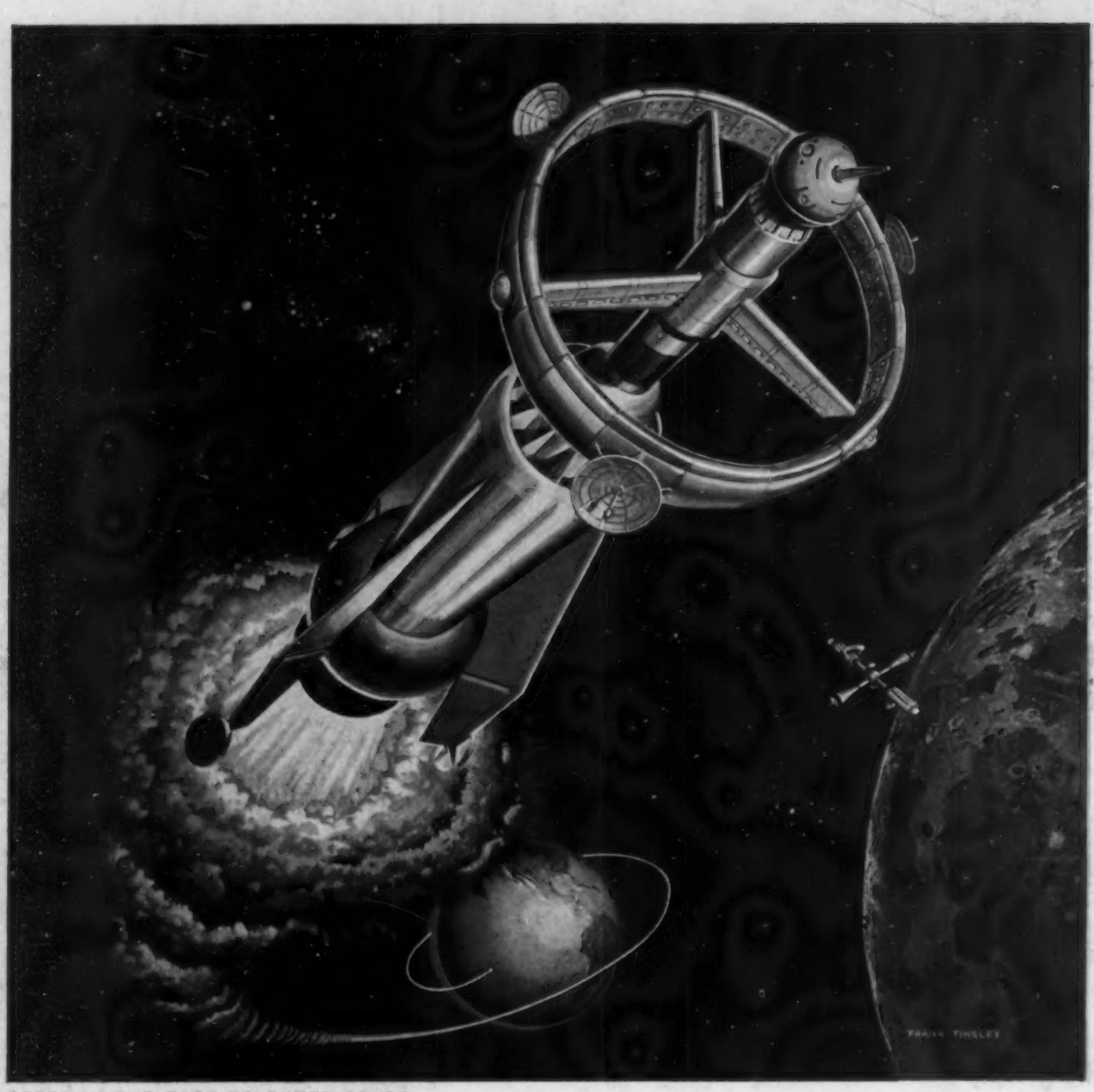

STEPS IN THE RACE TO OUTER SPACE

Atomic Pulse Rocket

This is the Atomic Pulse Rocket, a pot-bellied space ship nearly the size of the Empire State Building, propelled by a series of atomic blasts.

The enormous rocket (weighing 75,000 tons fully loaded) is designed to leave Earth with a thrust of 100,000 tons. Altogether a thousand atomic blasts—each equal to 1,000 tons of TNT—are fired from a low velocity gun into a heavy steel rocket engine at a rate of one per second until the vehicle leaves Earth's atmosphere. Then steam and vaporized steel maintain the thrust. After transit speed is reached, and the propulsion system shut off, power is provided by solar batteries plating the wing and body surfaces.

Inside the rocket, living quarters are situated in the rim of a pressurized wheel-like cabin which revolves to provide artificial gravity. Radio and radar antennae revolve with it. Tubular hydroponic "gardens" on either side of the rim grow algae to produce oxygen and high protein food.

The Atomic Pulse Rocket could transport payload to the Moon at $6.74 per lb., less than one quarter the prevailing air freight charges over equivalent distance.

A similar project is past the pilot-study stage in the Defense Department.

ARMA, now providing the inertial guidance system for the ATLAS ICBM and engaged in advanced research and development, is in the vanguard of the race to outer space. For this effort, ***ARMA*** needs scientists and engineers experienced in astronautics. ***ARMA***, Garden City, New York. A Division of American Bosch Arma Corporation.

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